

Sparks on the Moon

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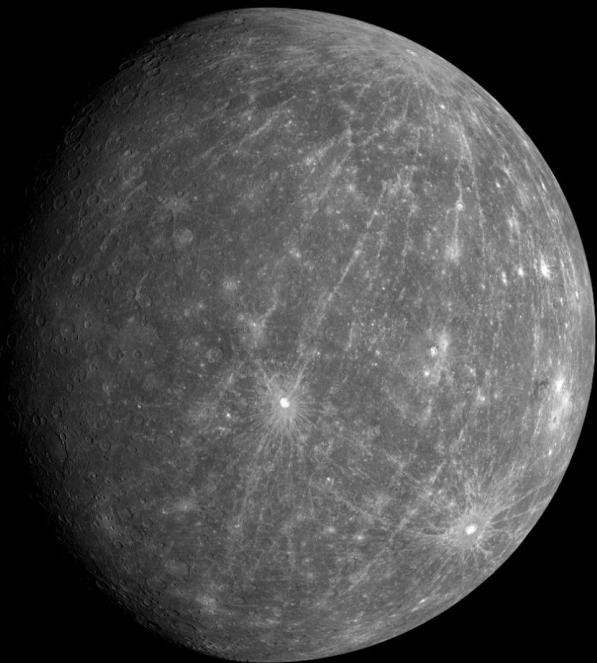
³ NASA Goddard Space Flight Center



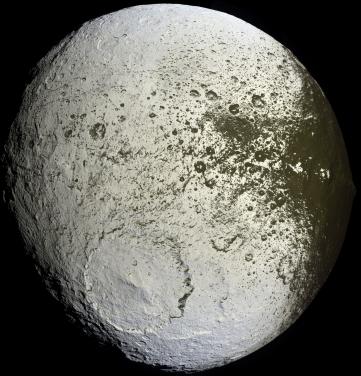
Moon



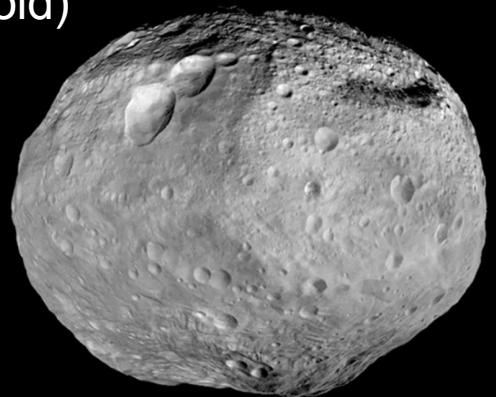
Mercury



Iapetus



Vesta
(asteroid)



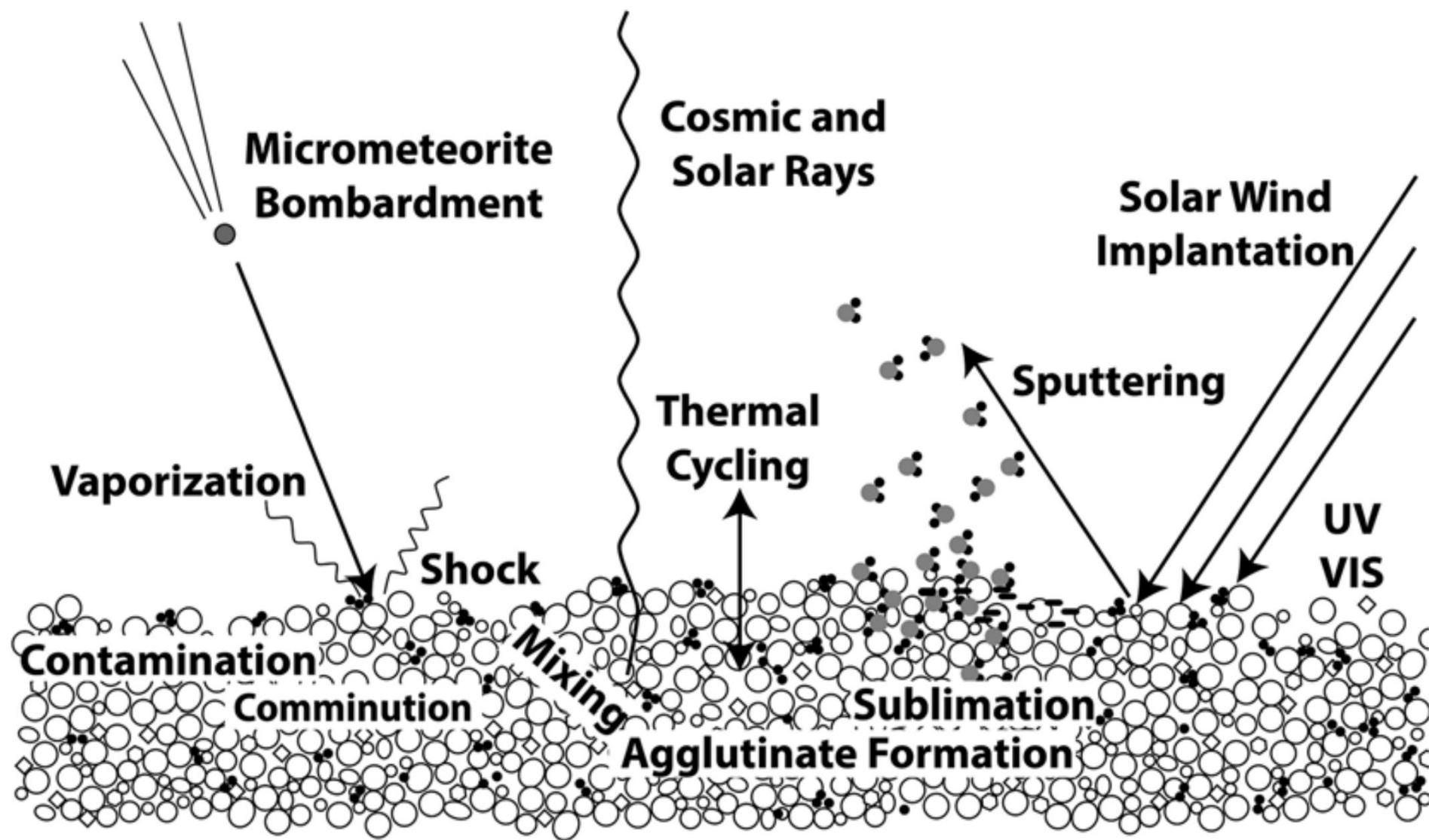
Phobos



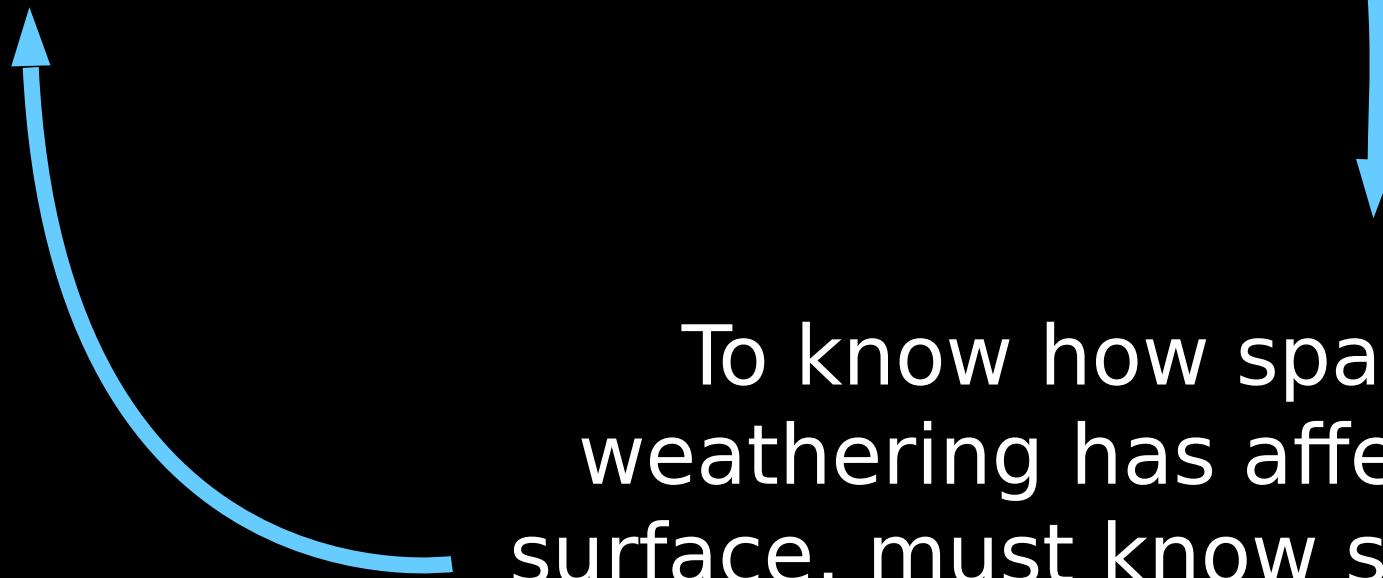
Charon and Pluto



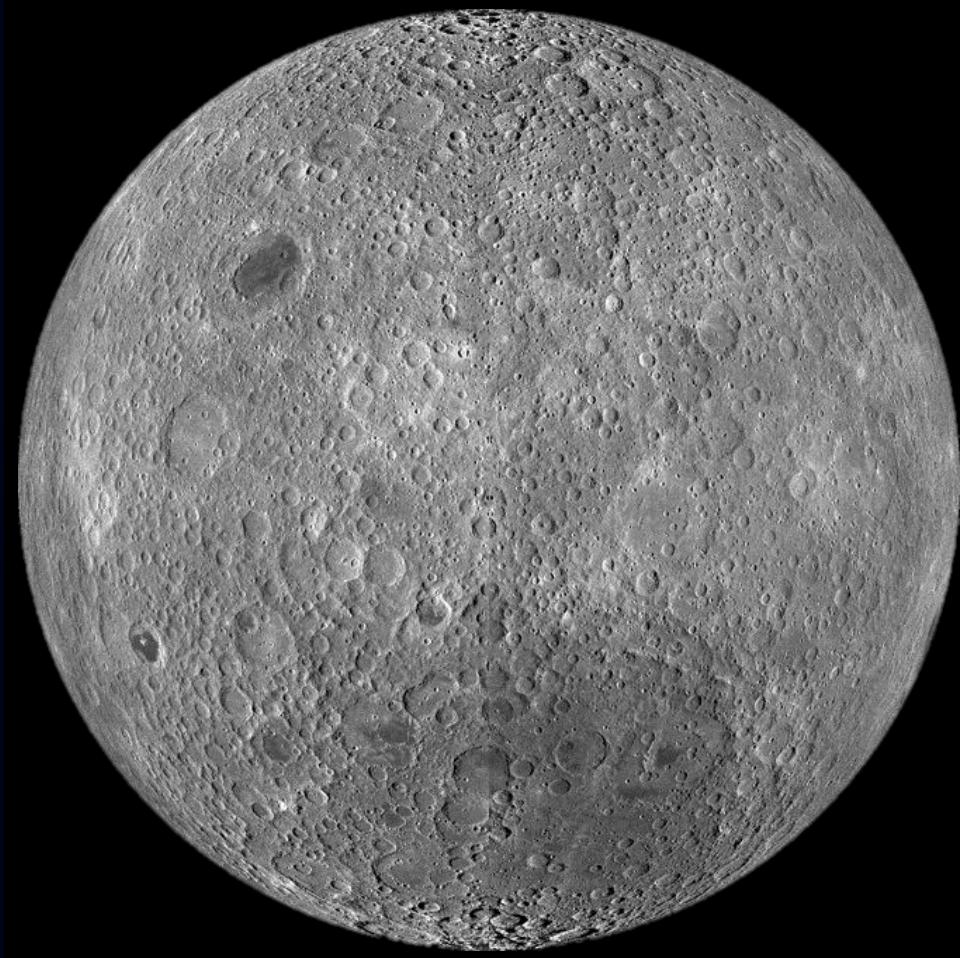
Space Weathering



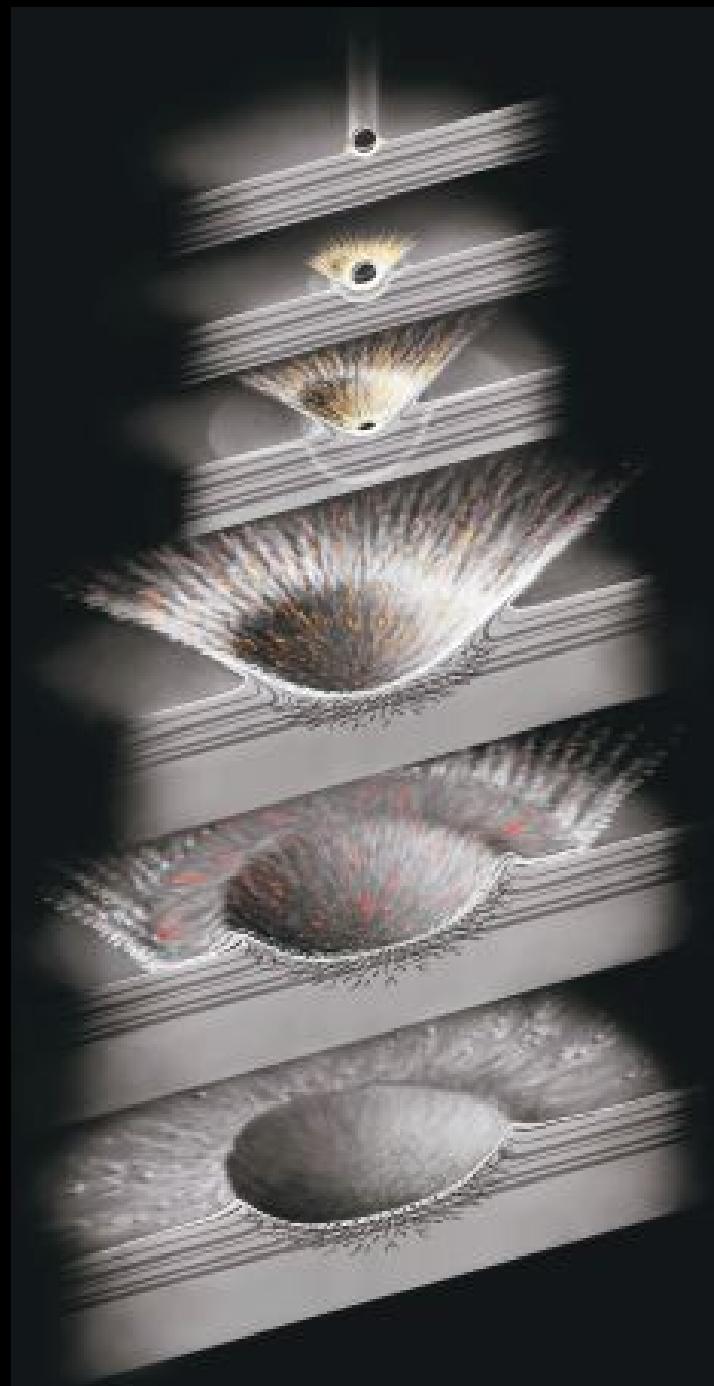
To determine surface properties via remote observations, must know how space weathering has affected surface



To know how space weathering has affected surface, must know surface properties and *all* space weathering processes



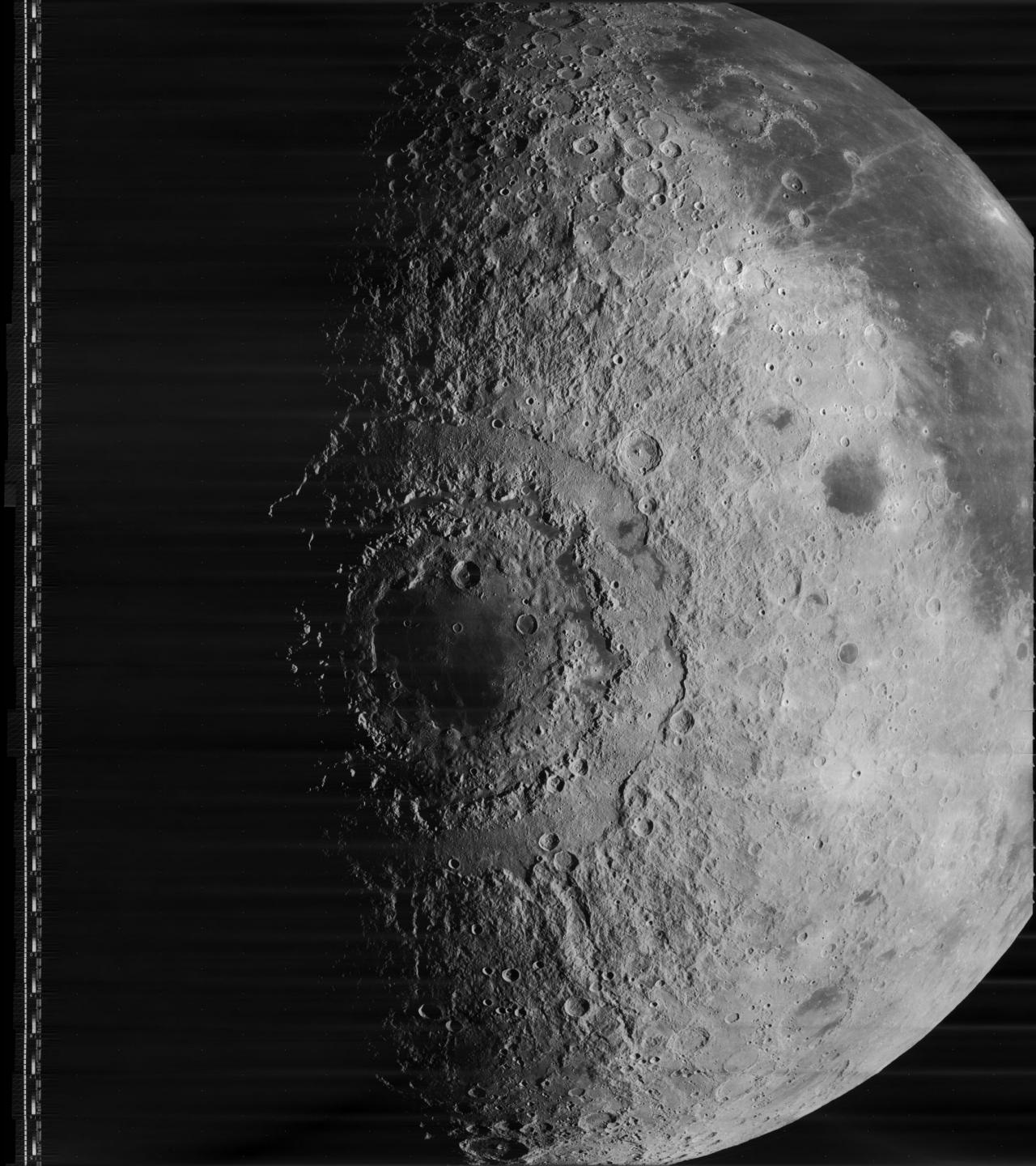
LROC WAC
(NASA/GSFC/Arizona State University)



(Pearson Education, Inc.)



LROC WAC
(NASA/GSFC/Arizona State University)



Lunar Orbiter
(NASA)

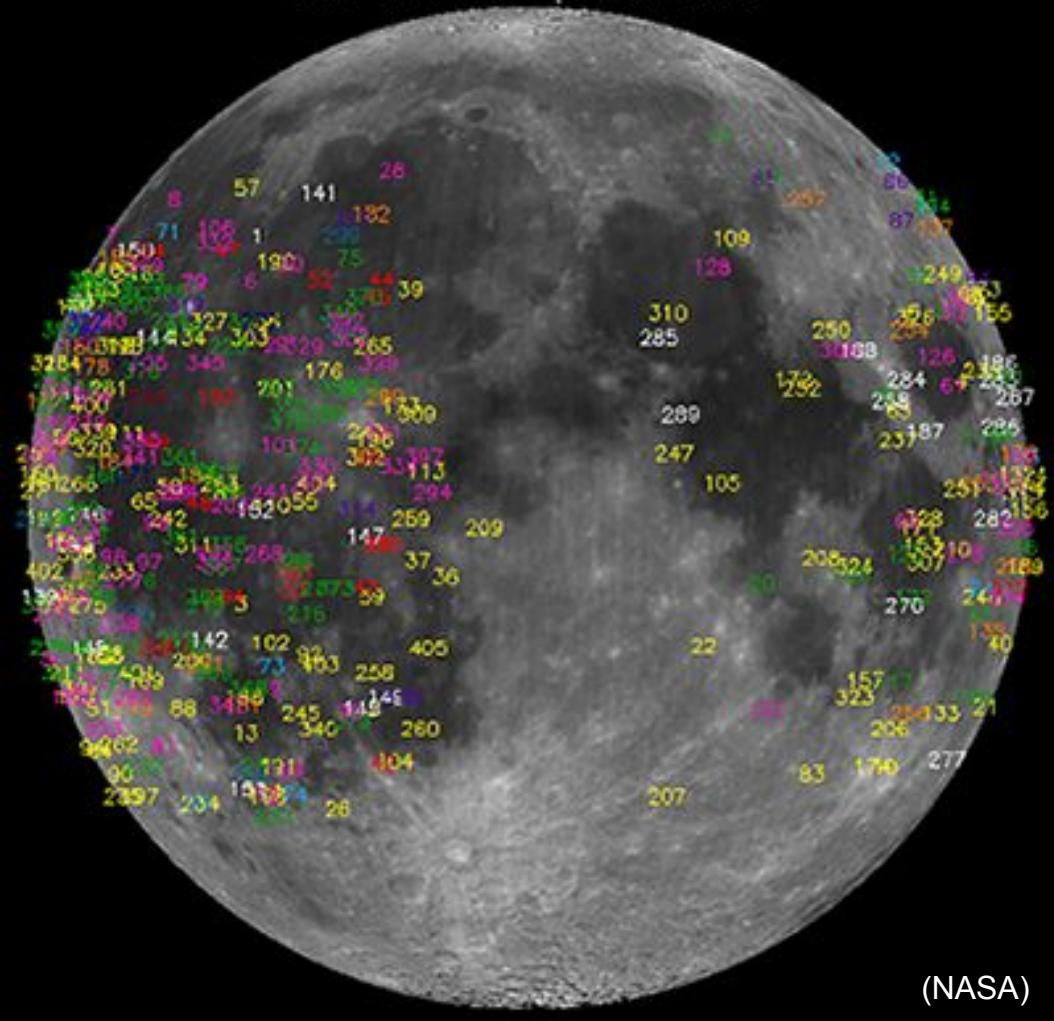
Jan. 4, 2008



(NASA)

2005–2017 MEO Impact Candidates

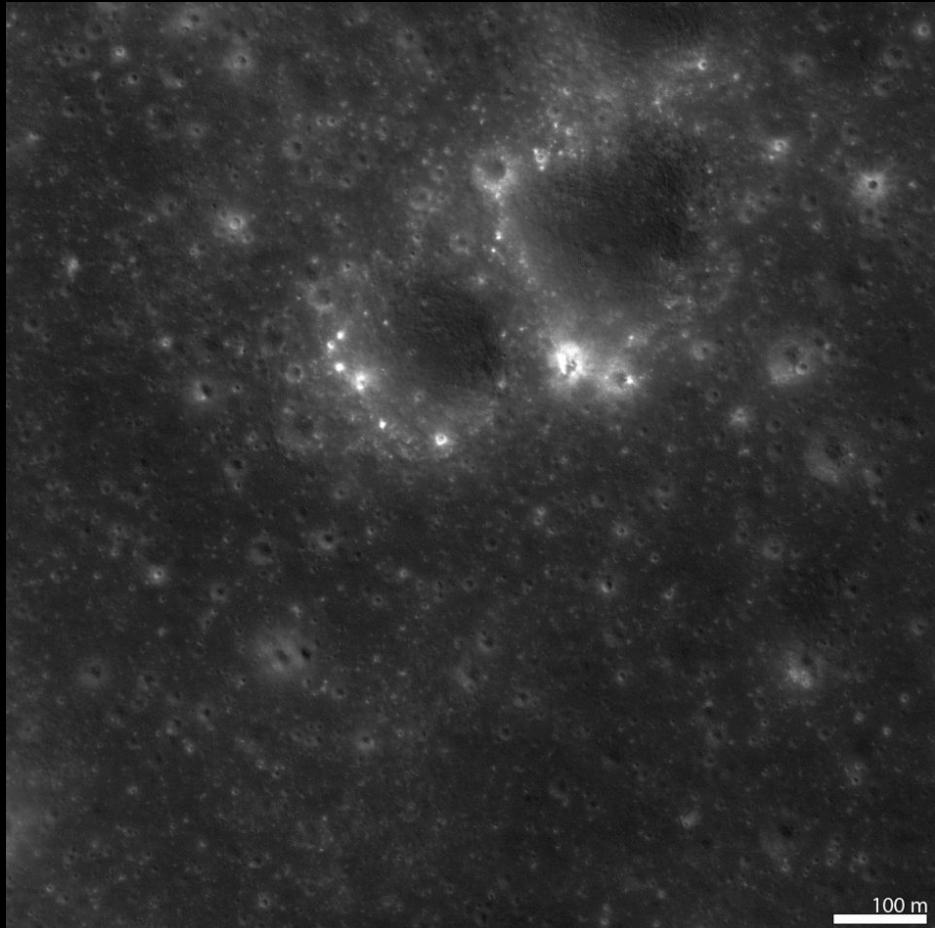
Jan. 4, 2008



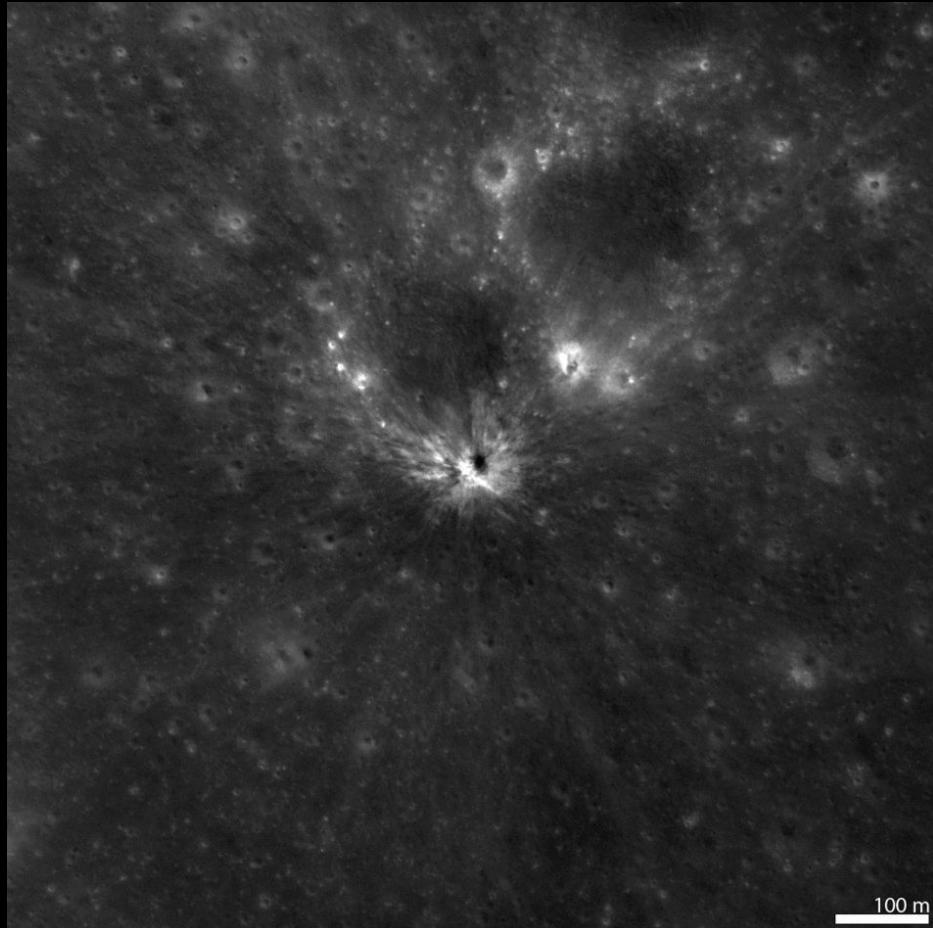
(NASA)

(NASA)

Sep. 11, 2013



Before



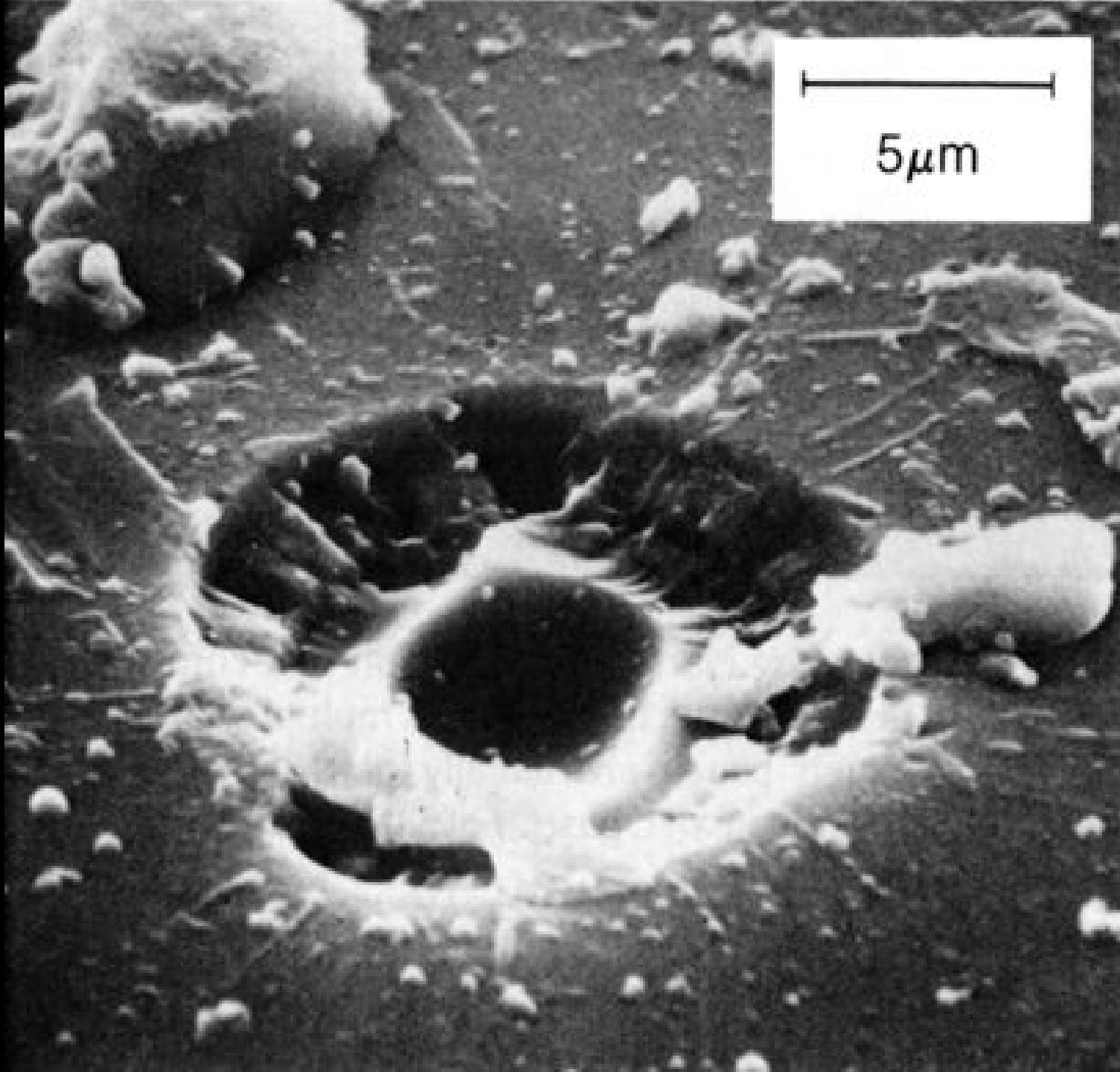
After

LROC NAC
(NASA/GSFC/Arizona State University)

Lunar sample 61195
from Apollo 16



(NASA)



(McKay et al., 1991)



(NASA)



Apollo 17: Eugene Cernan
(NASA)



Apollo 17: Eugene Cernan
(NASA)



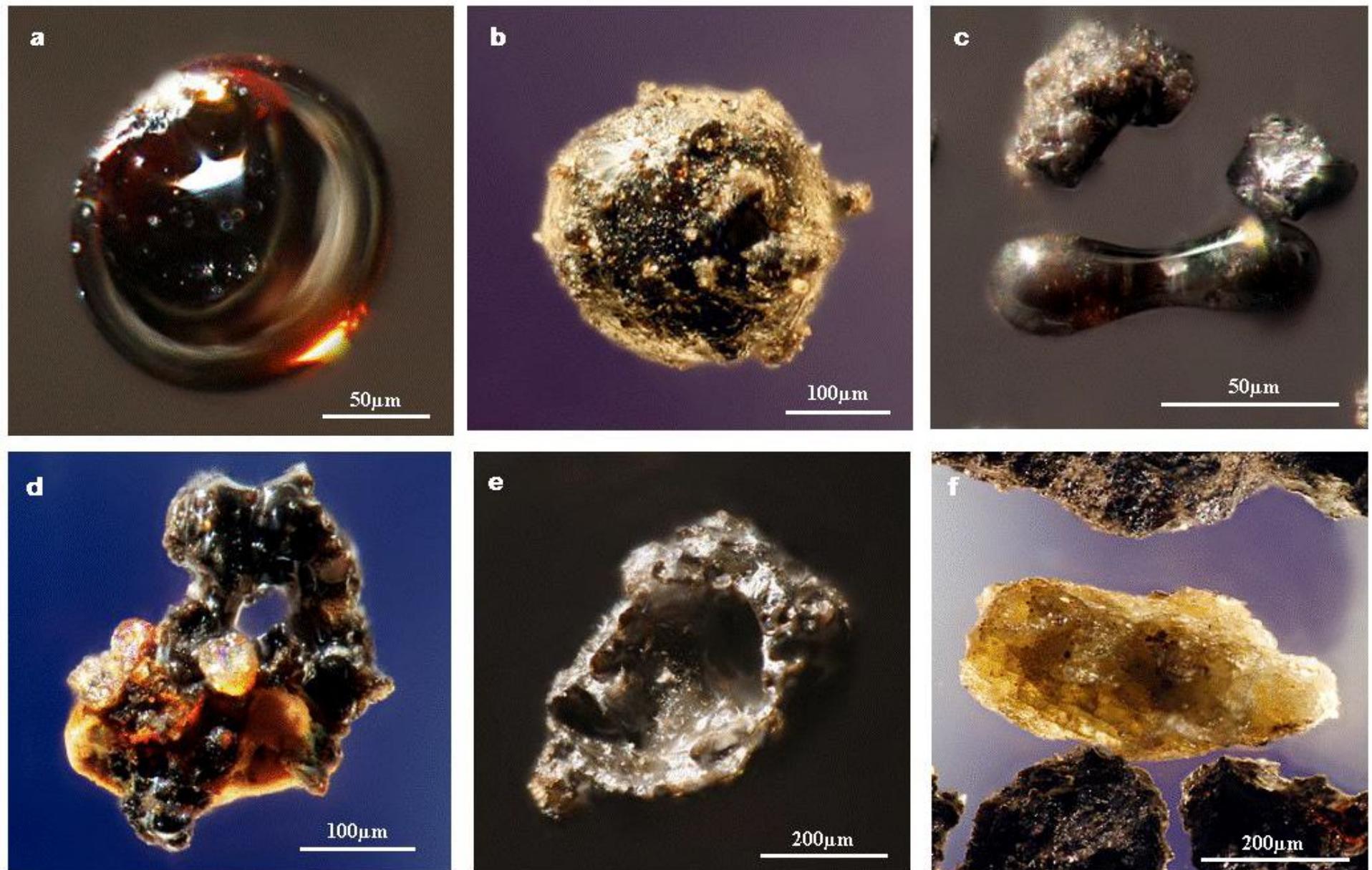
Apollo Lunar Surface Closeup Camera
(NASA)



Apollo 11: Buzz Aldrin
(NASA)



Apollo Lunar Surface Closeup Camera
(NASA)



(Greenberg et al., 2010)

The background of the image is a dark, monochromatic texture that resembles the surface of the Moon or a similar celestial body. It features large, irregular rock formations and smaller, finer particles that create a sense of depth and geological complexity.

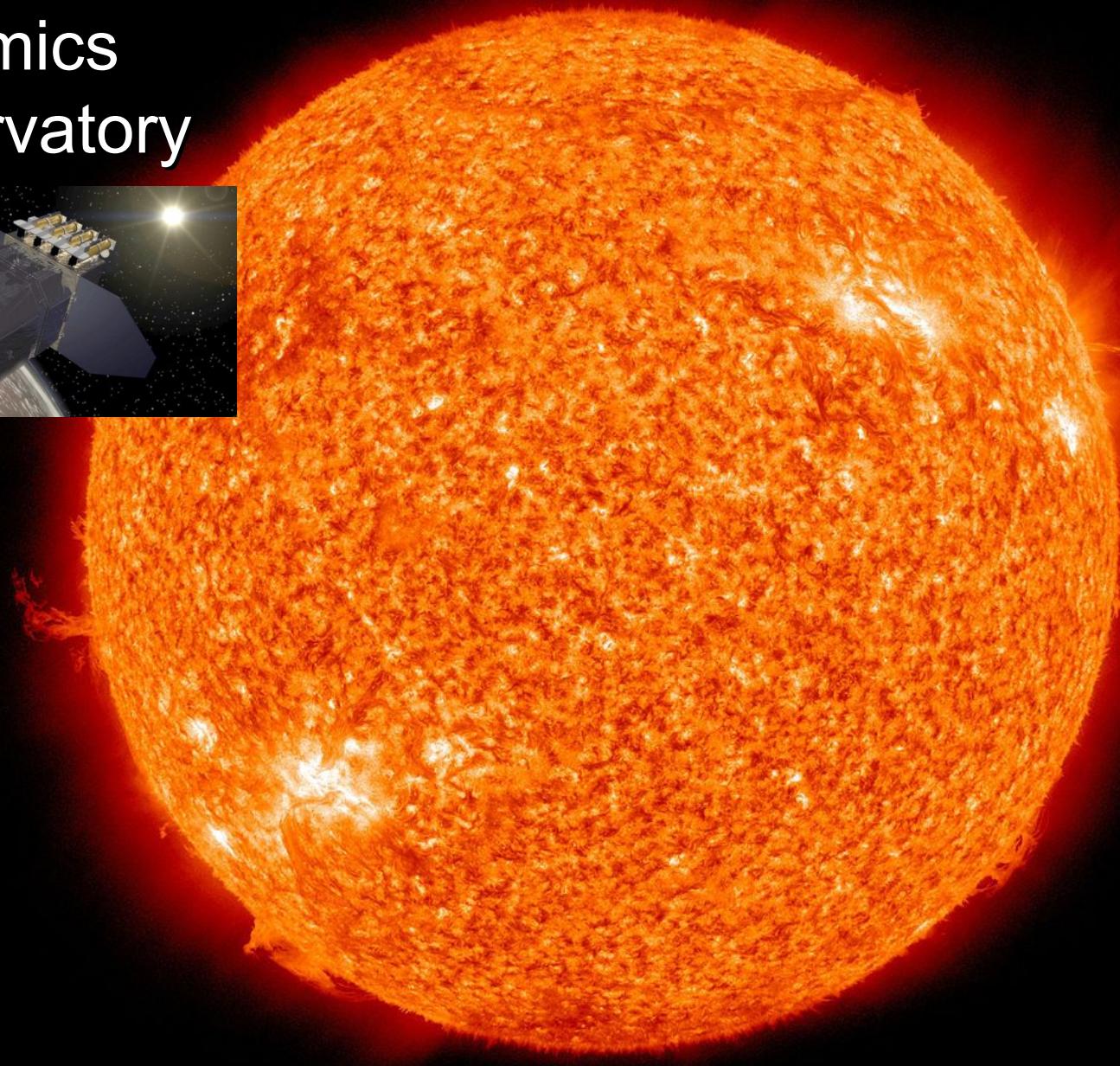
Impacts create regolith, including soil.

Here comes the Sun.



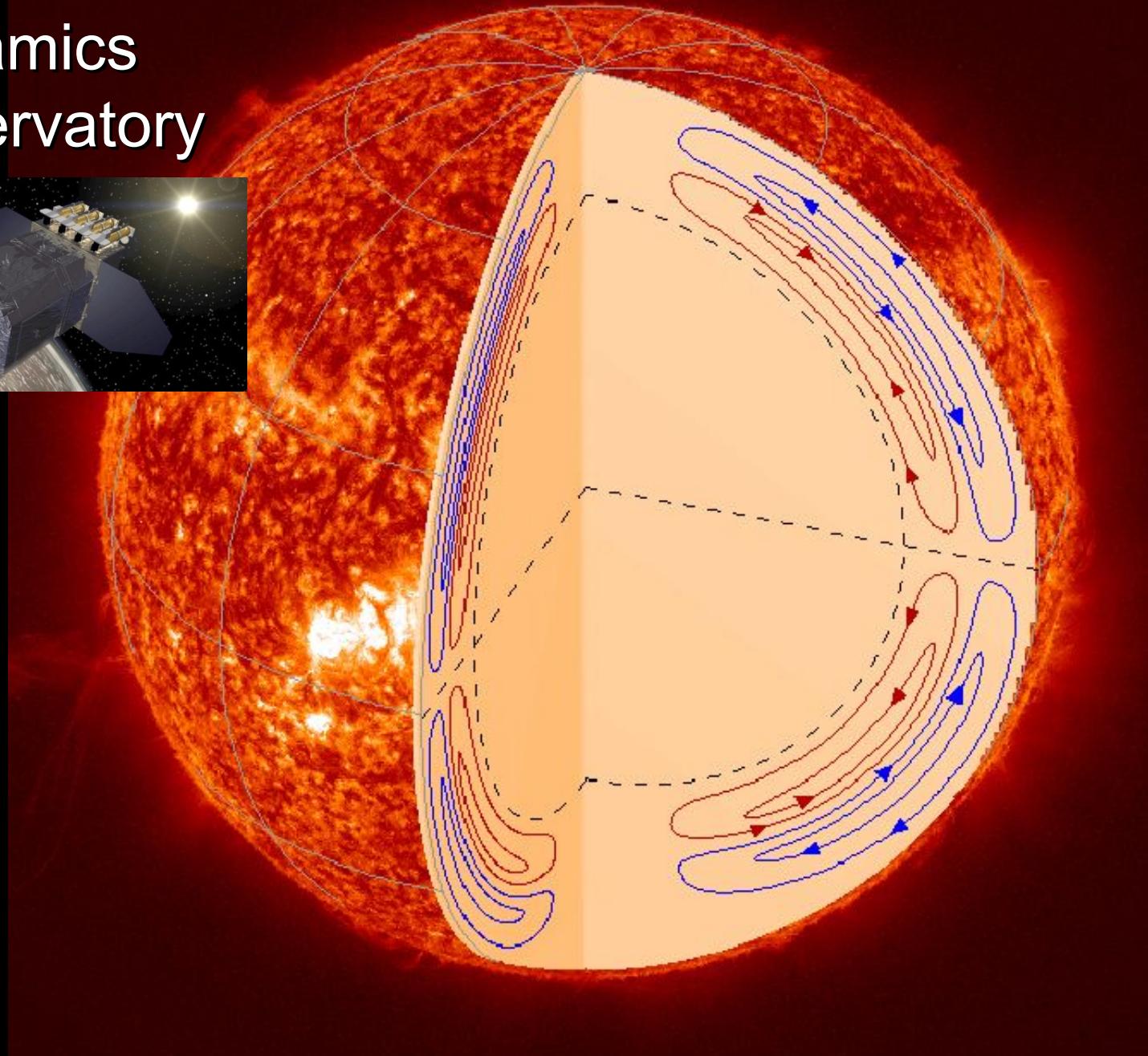
SDO
(NASA)

Solar Dynamics Observatory



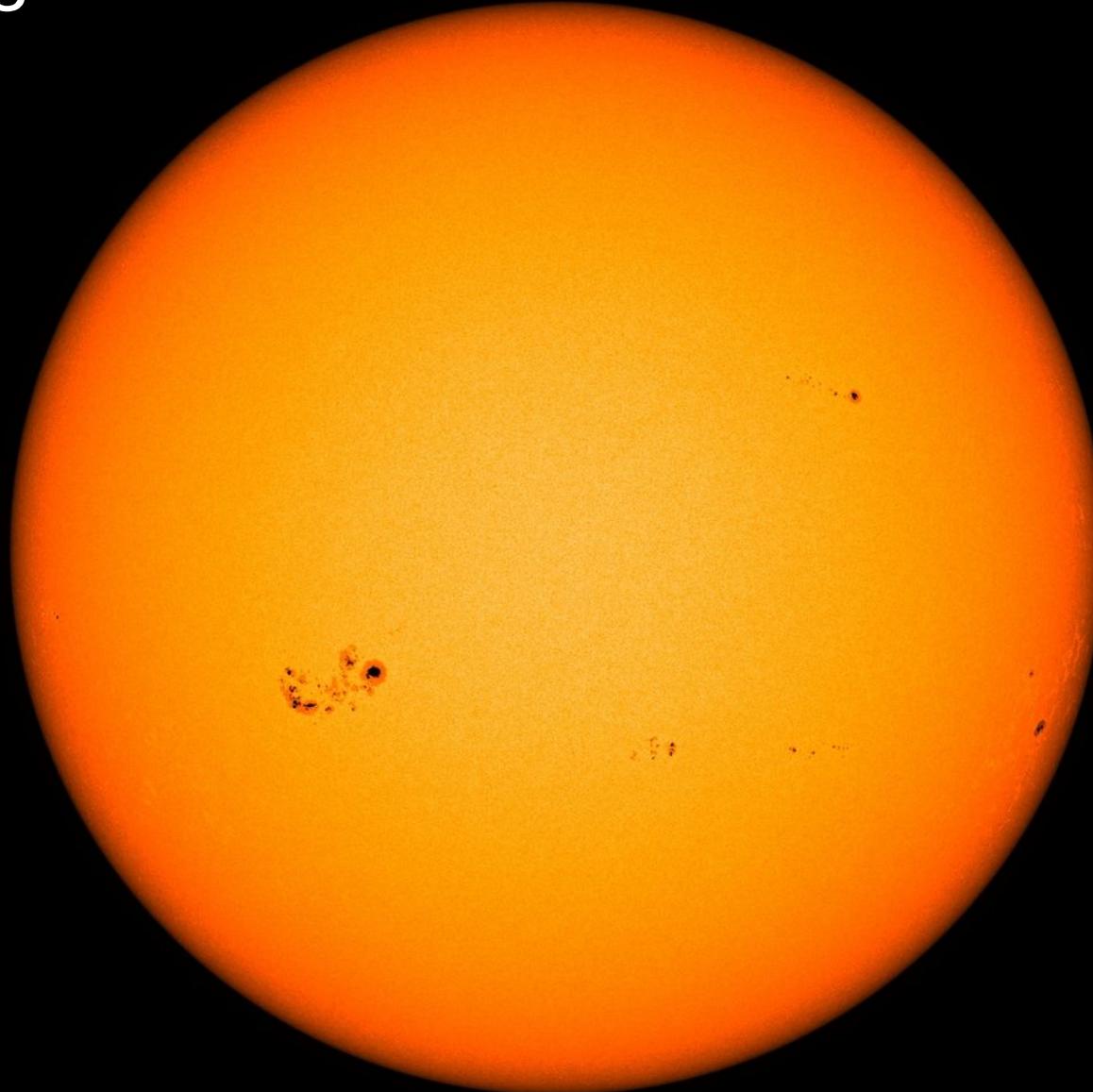
SDO
(NASA)

Solar Dynamics Observatory



SDO
(NASA)

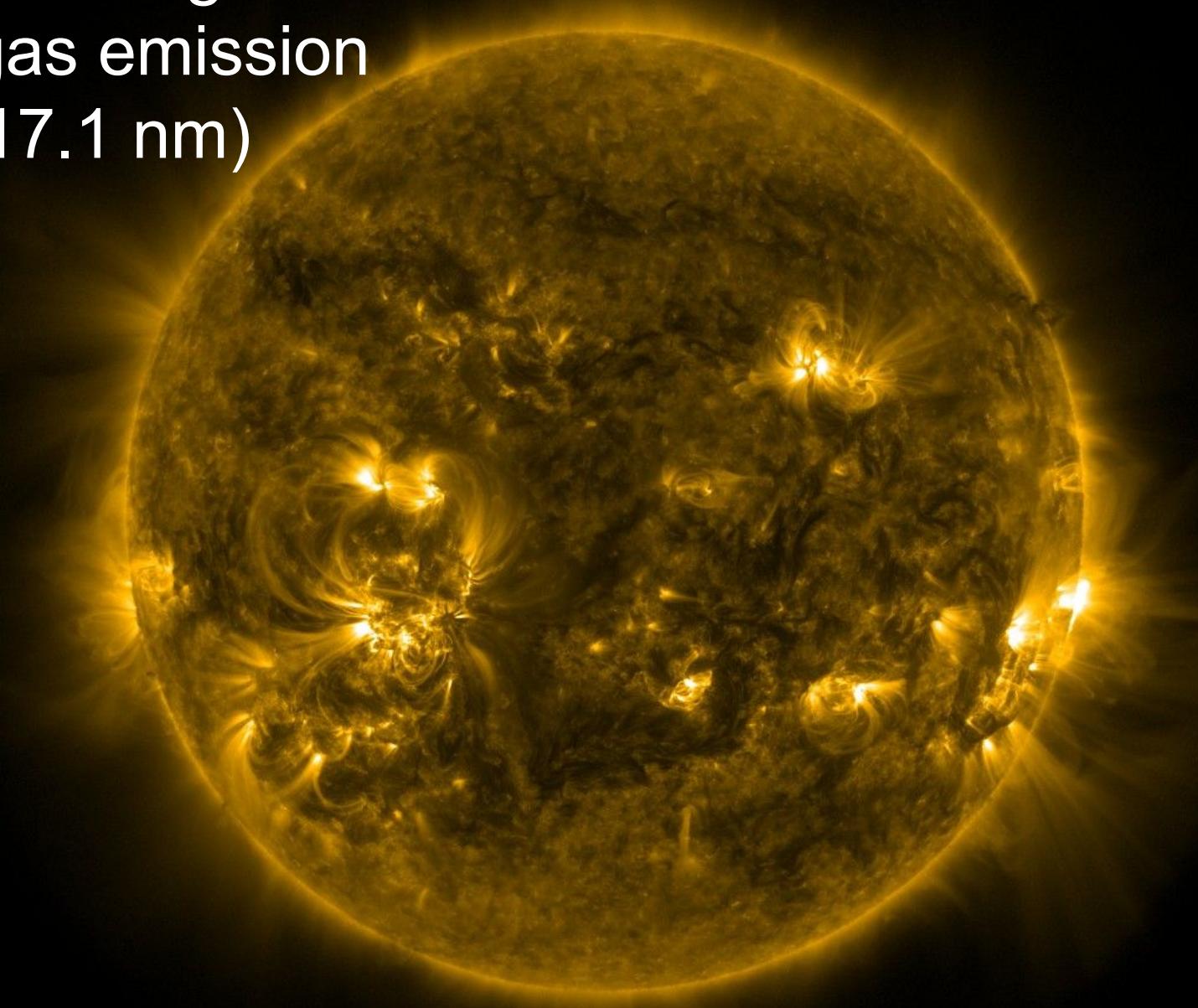
Visible light



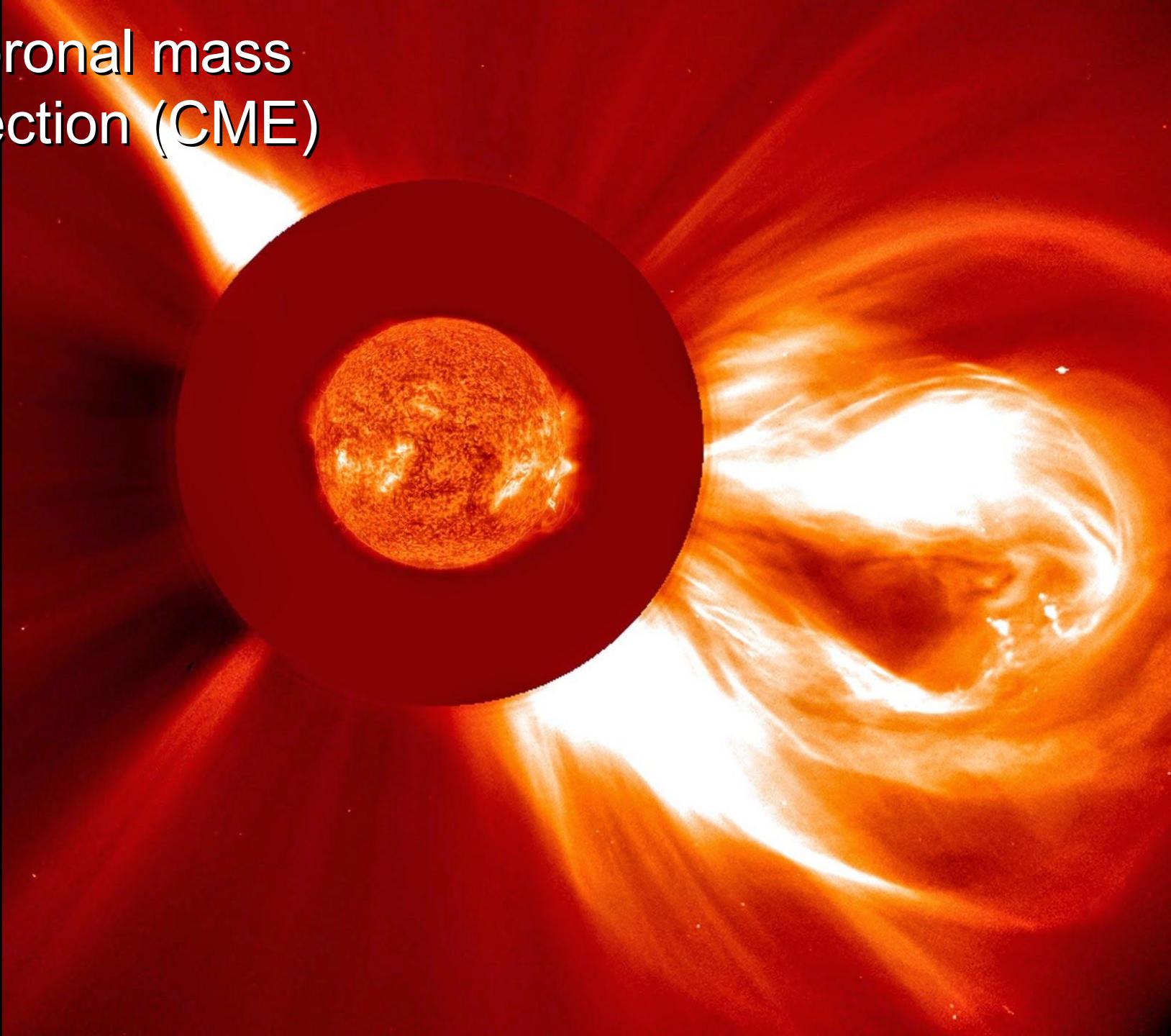
SDO/HMI Quick-Look Continuum: 20131107_001500

SDO
(NASA)

Ultraviolet light: Iron gas emission line (17.1 nm)

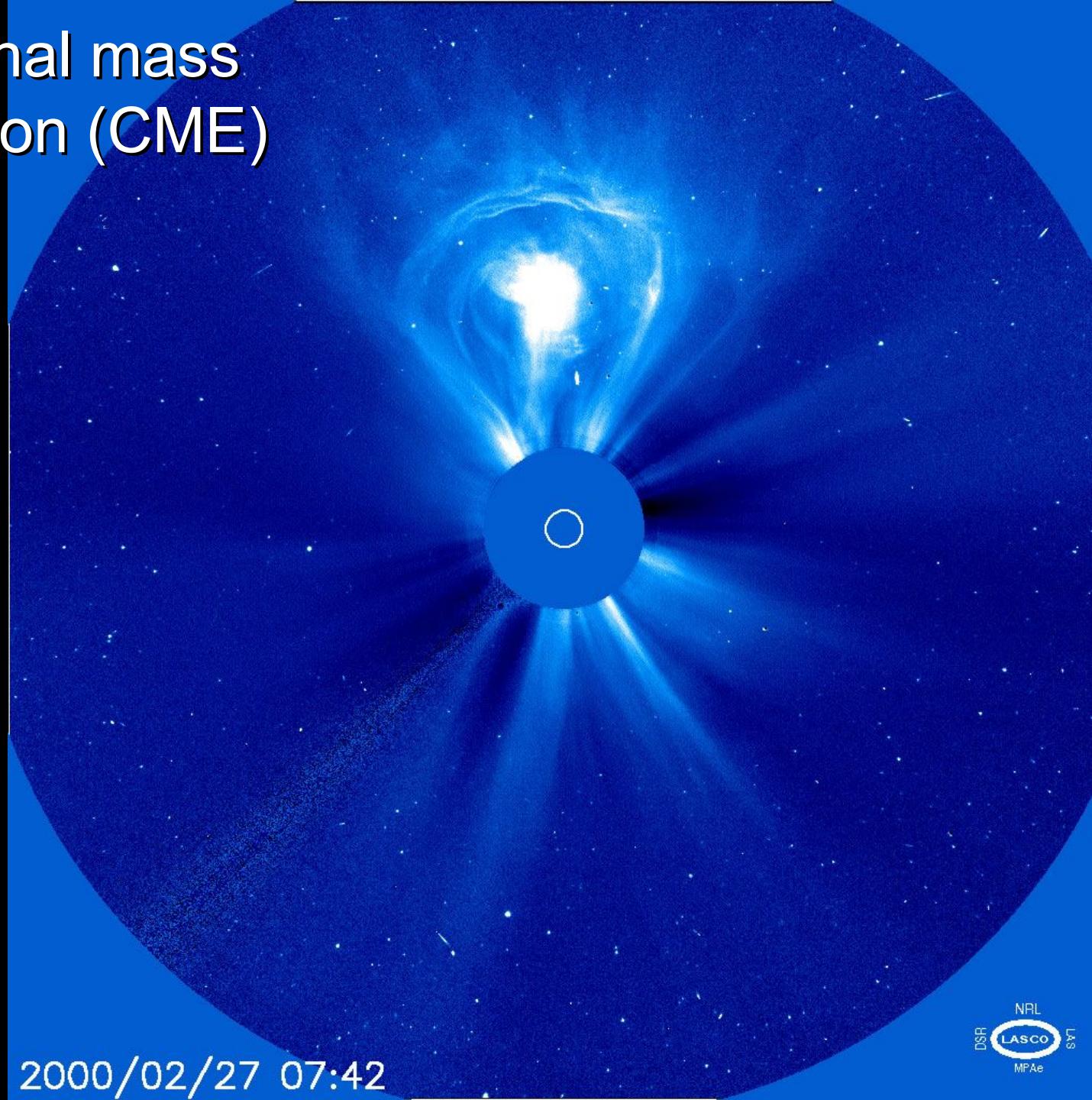


Coronal mass ejection (CME)



SOHO
(NASA)

Coronal mass ejection (CME)

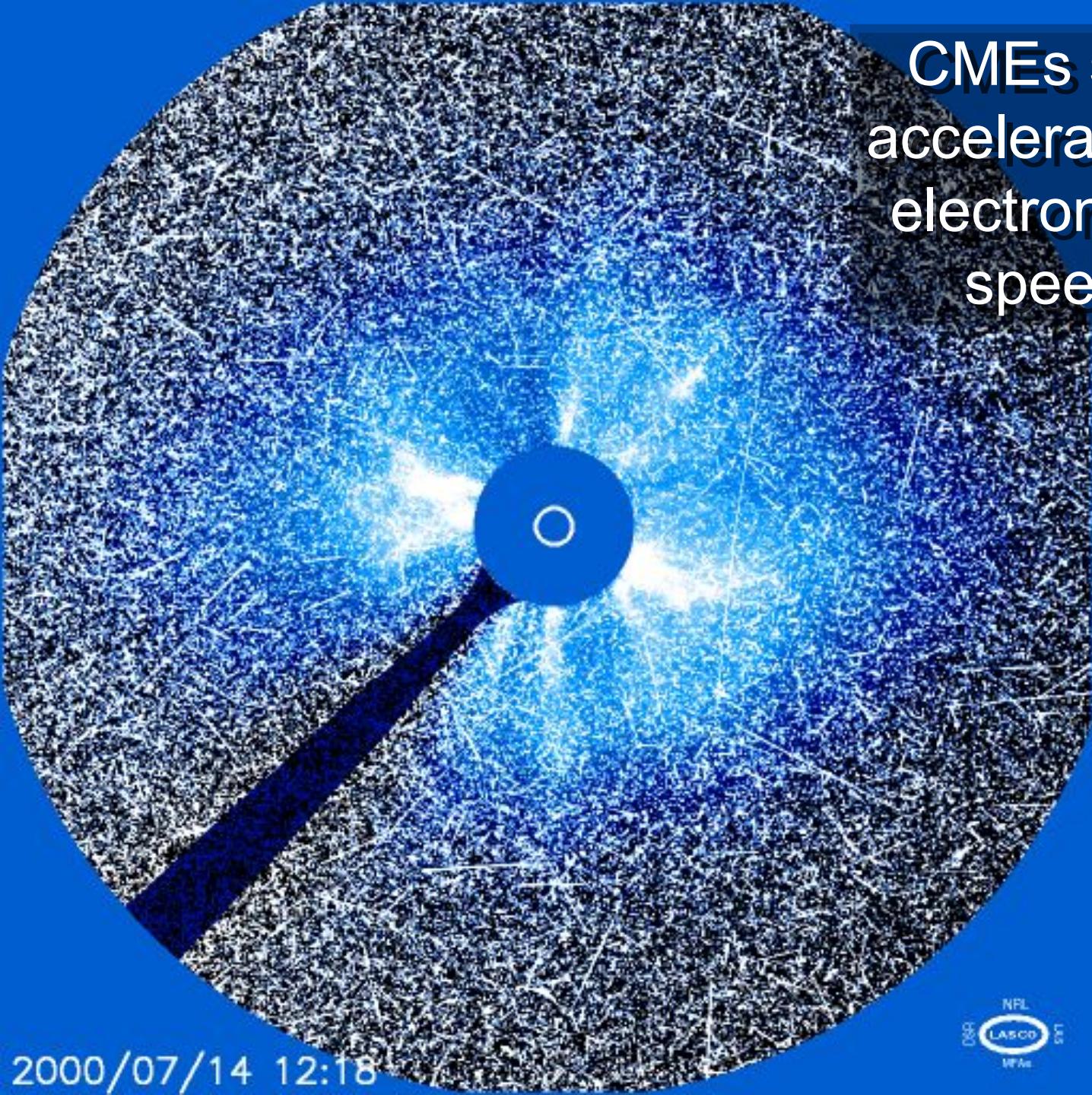


2000/02/27 07:42

NRL
SOHO
LASCO
SE
MPAe

SOHO
(NASA)

CMEs sometimes
accelerate protons &
electrons almost to
speed of light

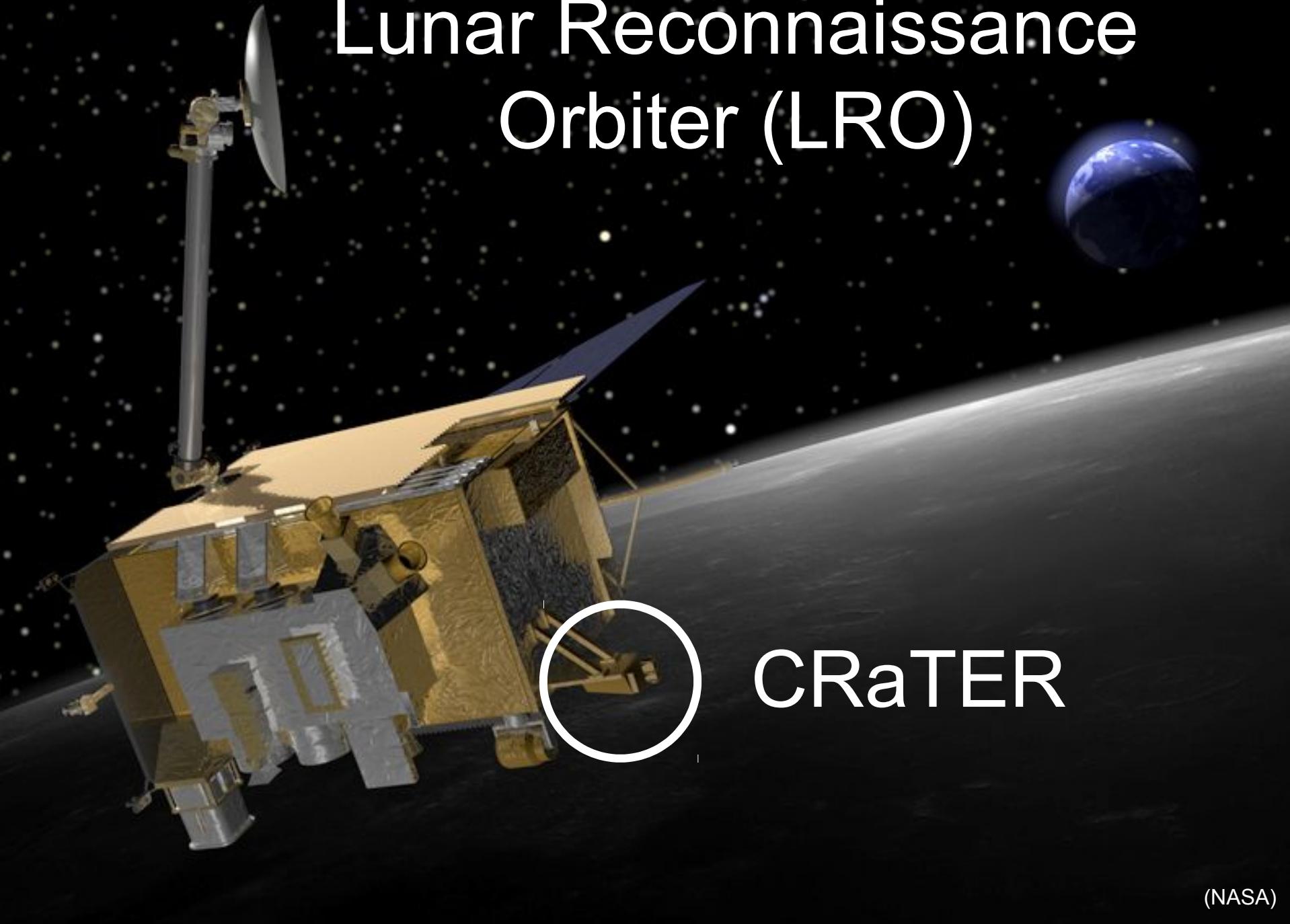


2000/07/14 12:18

NRL
LASCO C2
WFOV

SOHO
(NASA)

Lunar Reconnaissance Orbiter (LRO)



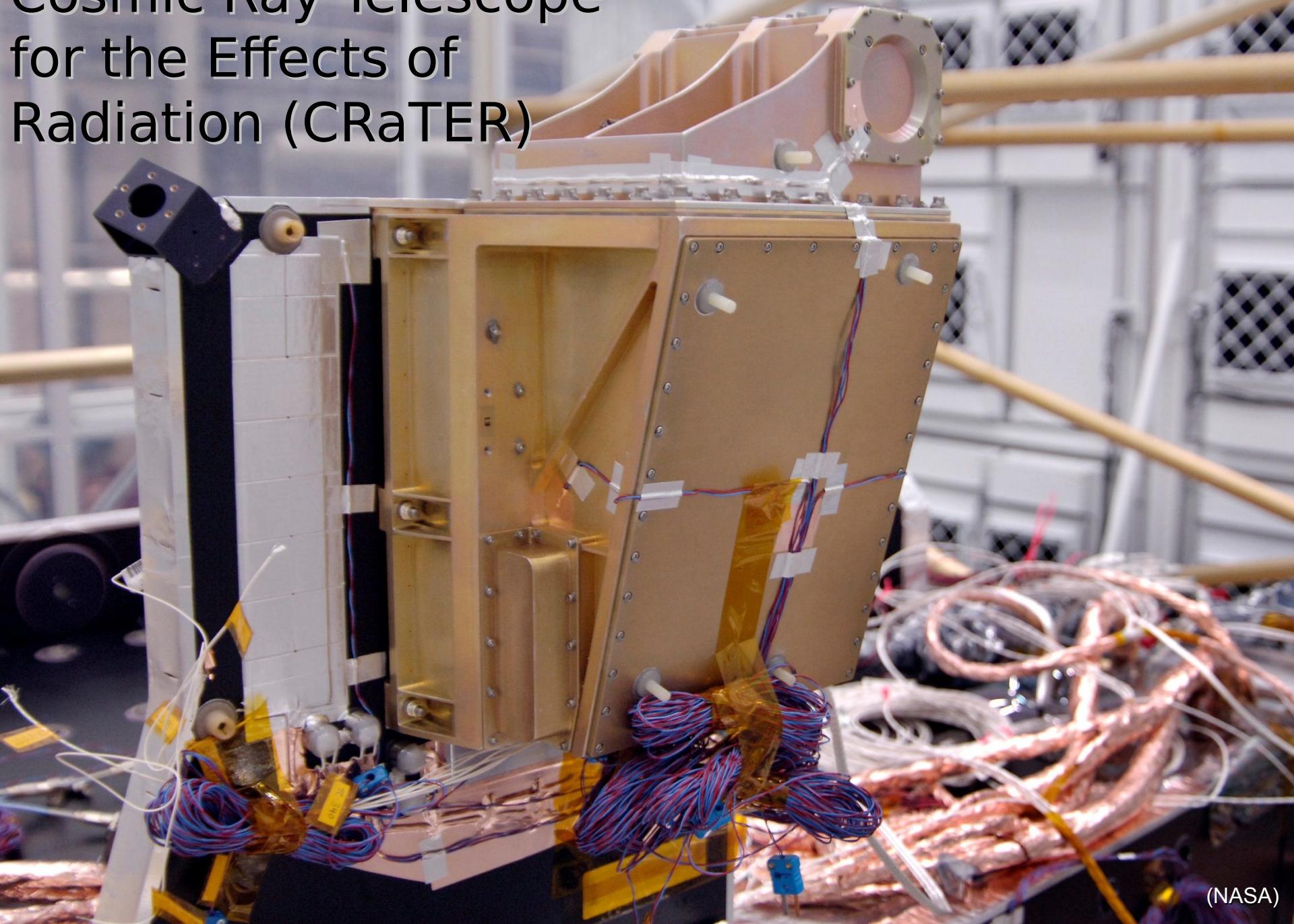
CRaTER

Lunar Reconnaissance Orbiter (LRO)



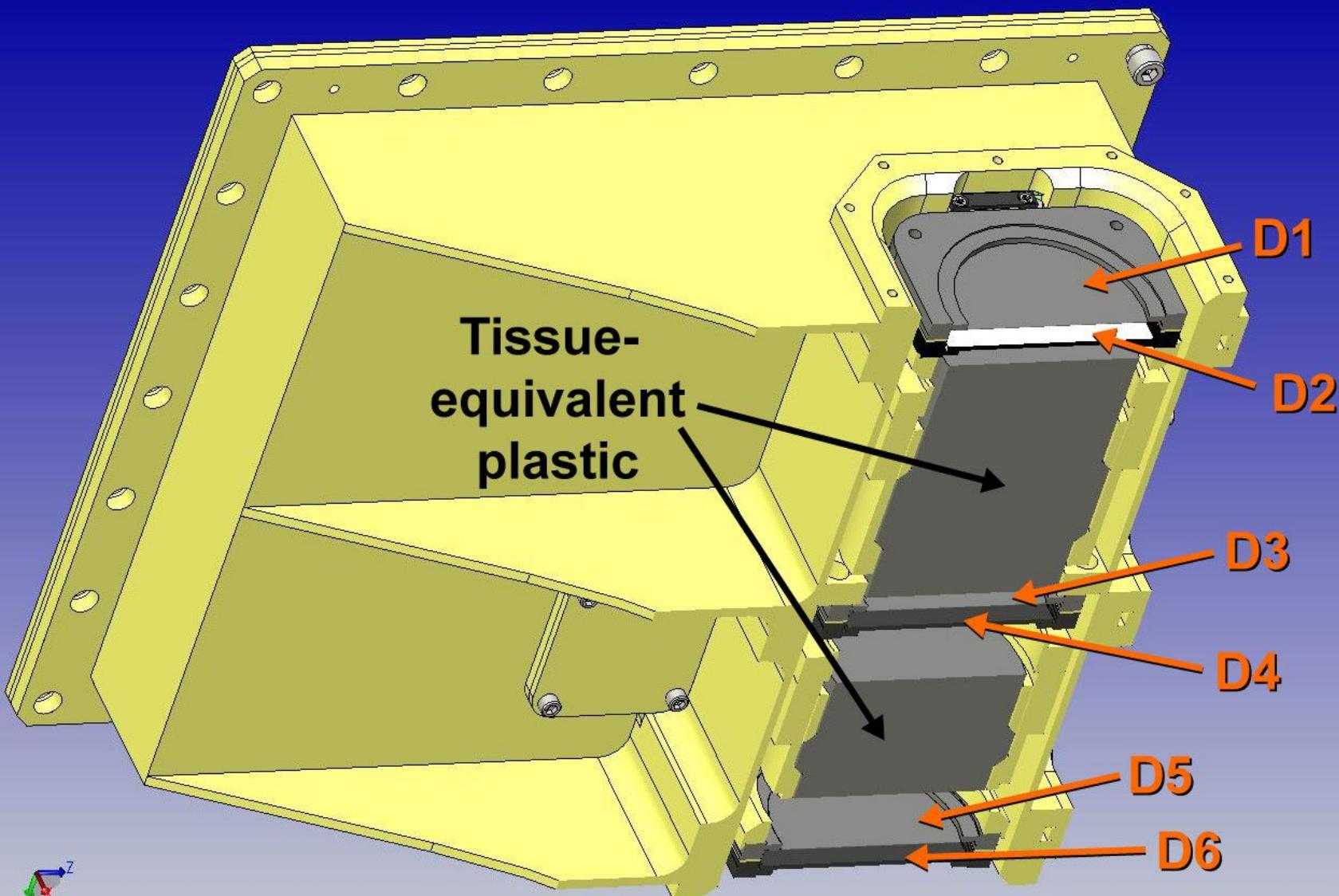
(NASA)

Cosmic Ray Telescope for the Effects of Radiation (CRaTER)



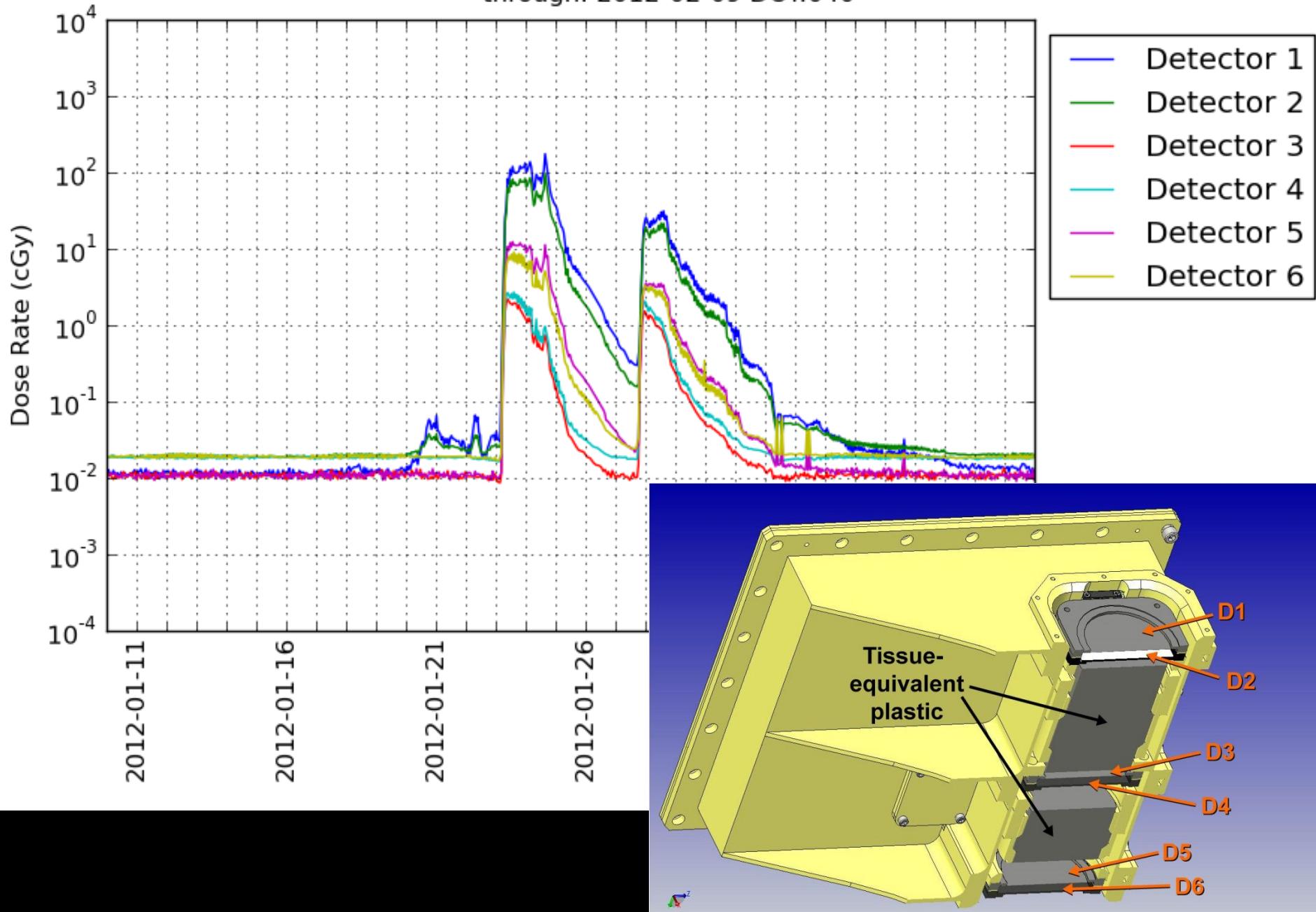
(NASA)

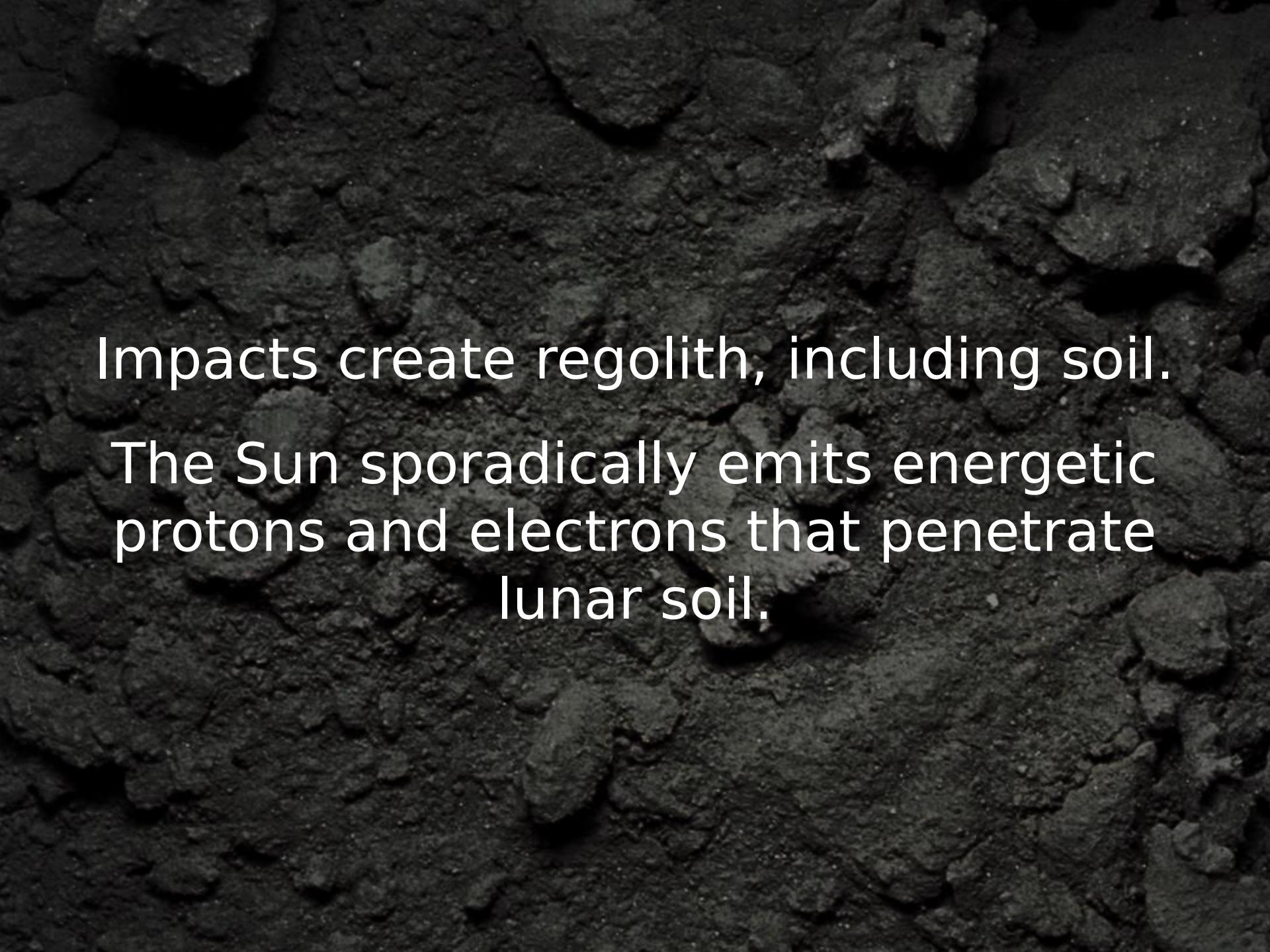
Toward space



Toward the Moon

CRaTER 31 day individual detectors dose rate data
from: 2012-01-10 DOY:010
through: 2012-02-09 DOY:040



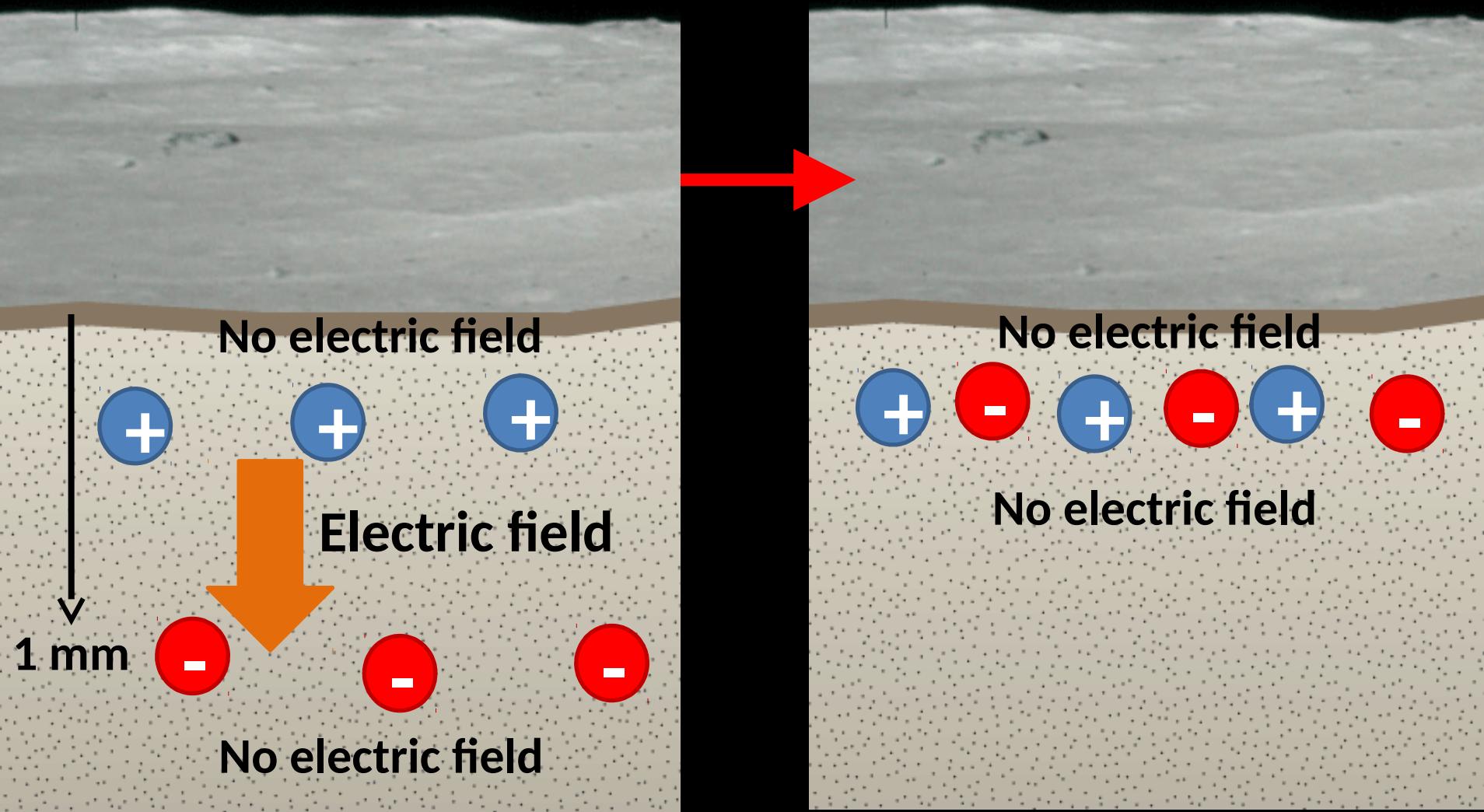
The background of the slide is a dark, monochromatic image showing a close-up, high-contrast view of a textured surface. It appears to be a mix of dark rock fragments and fine, granular material, possibly lunar regolith or a similar extraterrestrial soil. The lighting is low, emphasizing the shadows and highlights on the irregular rock shapes.

Impacts create regolith, including soil.

The Sun sporadically emits energetic
protons and electrons that penetrate
lunar soil.

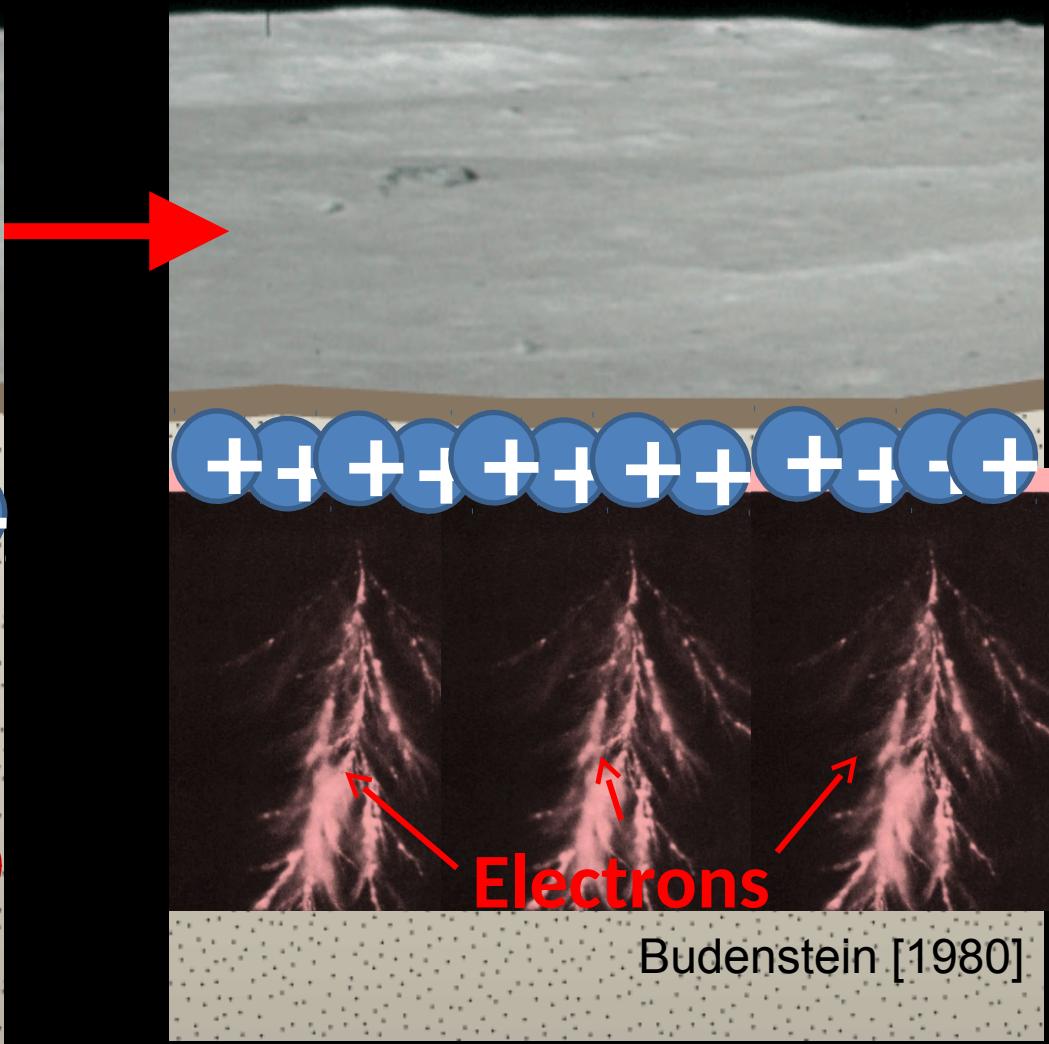
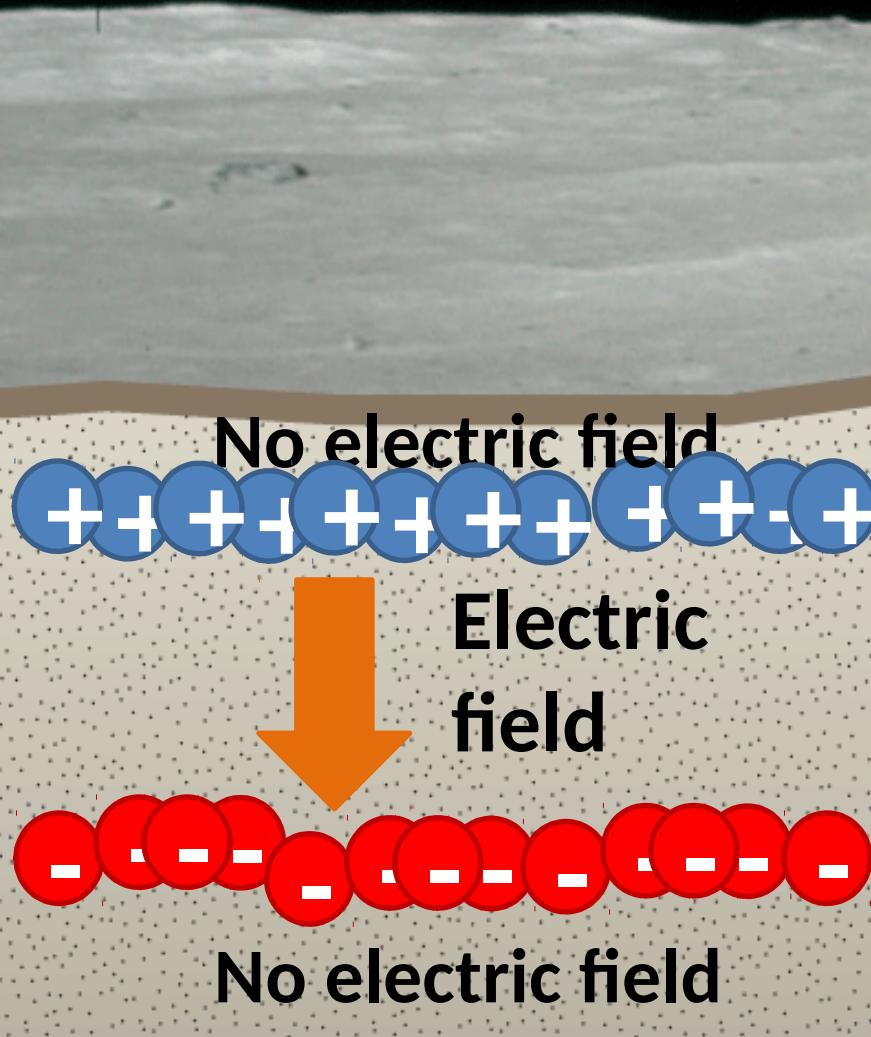
1) SEPs charge the subsurface, setting up a capacitor-like situation

2) Charging dissipates as in a capacitor



If SEPs charge regolith faster
than it can discharge...

... electric field can increase to
threshold for dielectric
breakdown



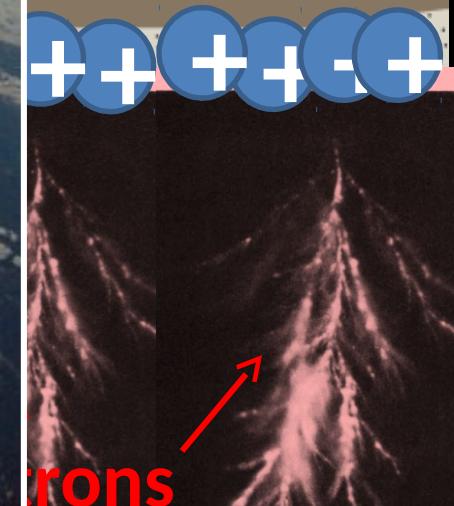
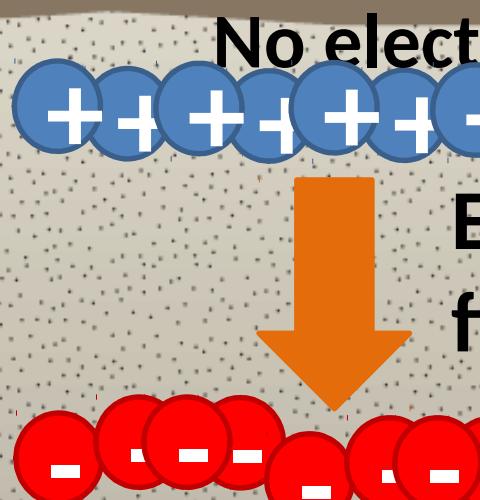
If SEPs charge regolith faster
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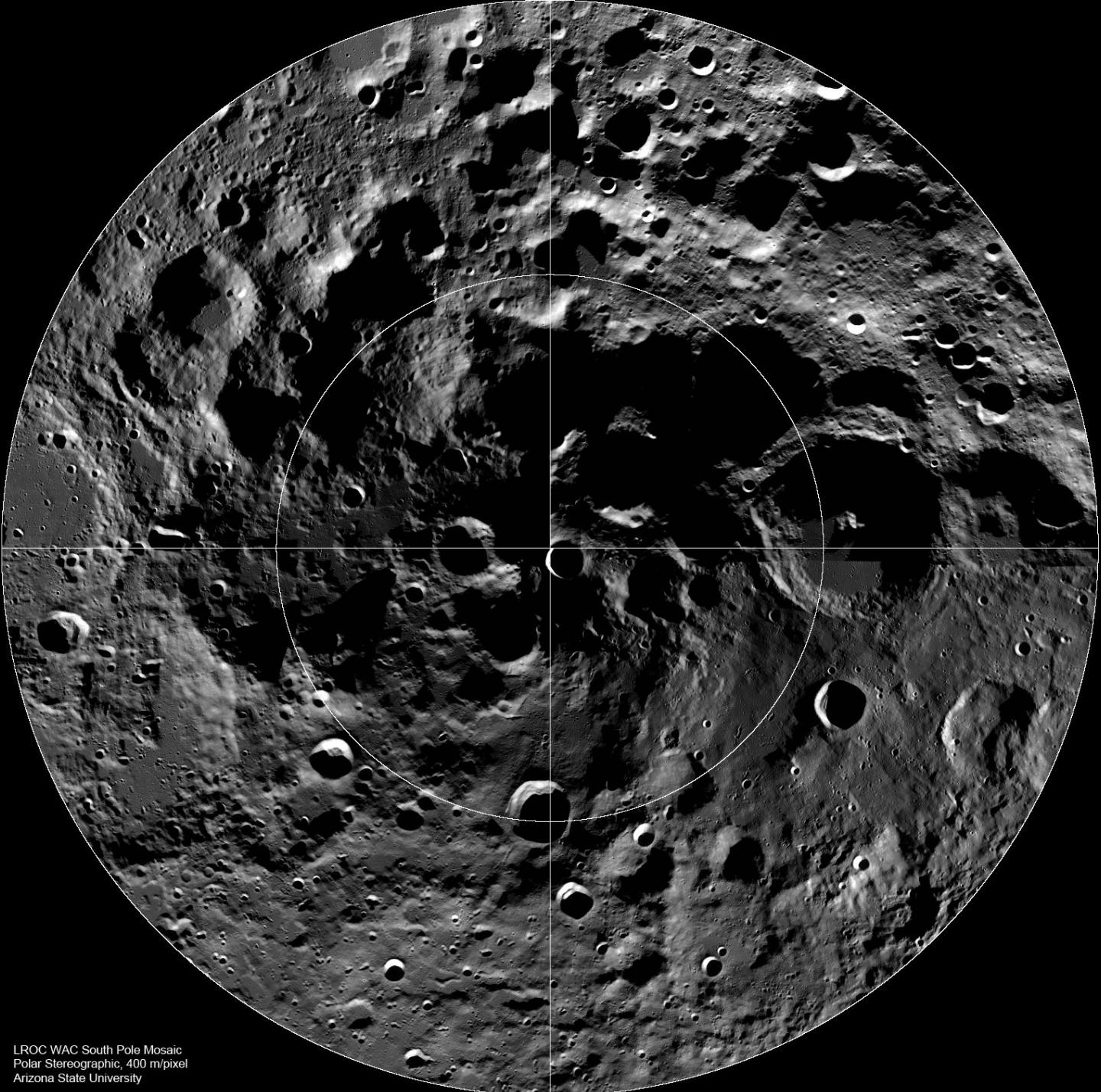
Combined Release and
Radiation Effects Satellite
(CRRES)



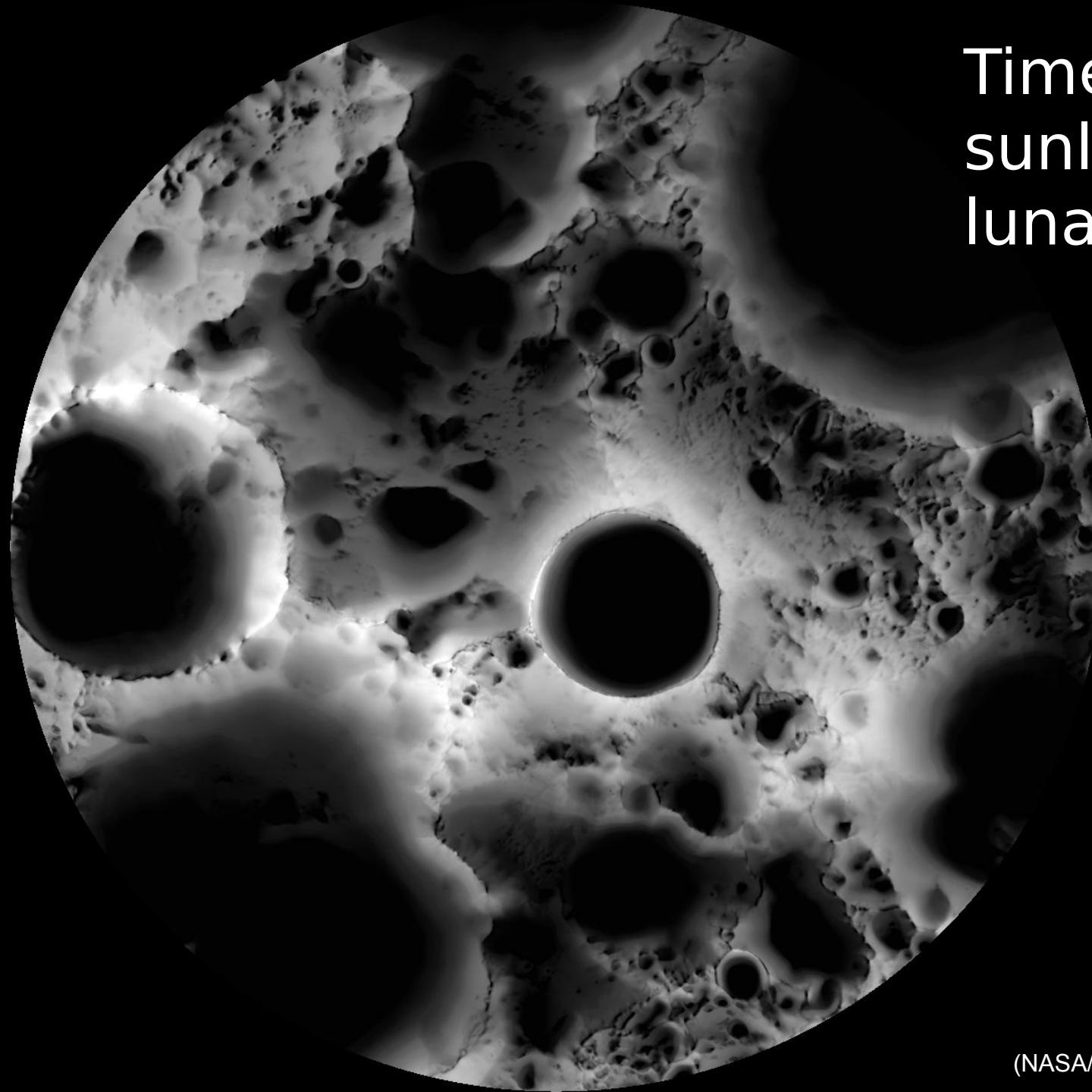
(NASA)



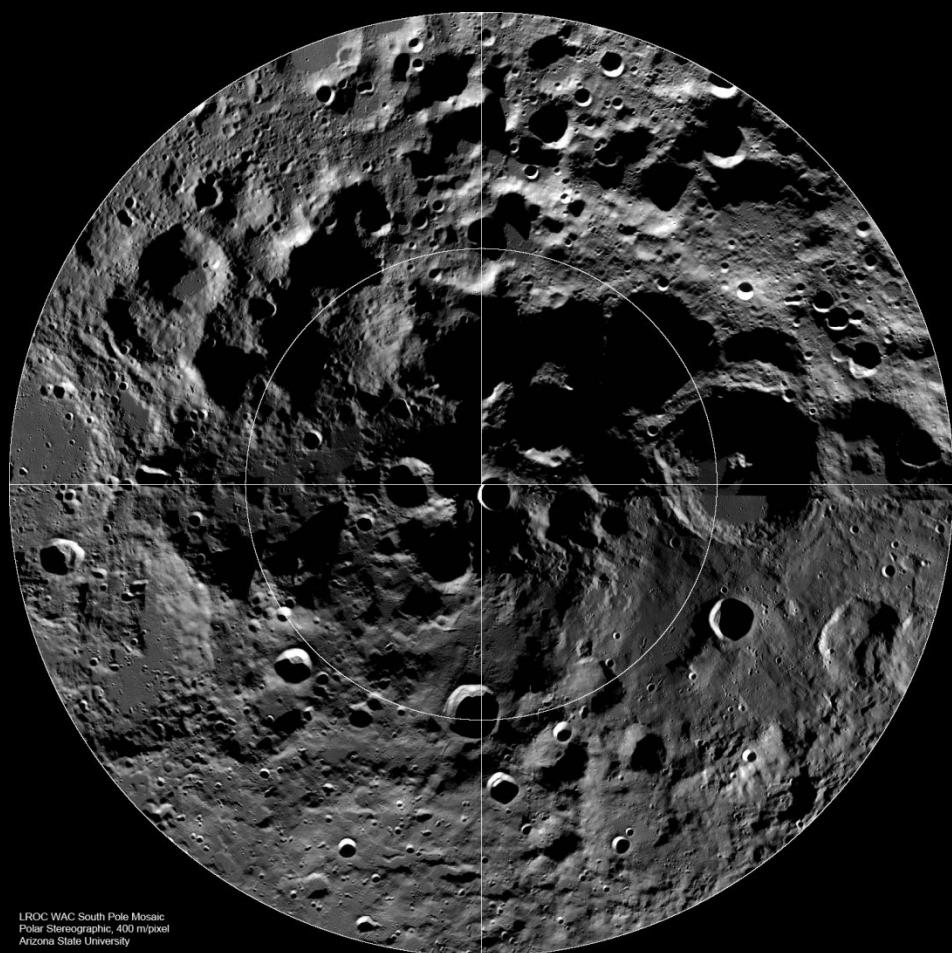
Budenstein [1980]



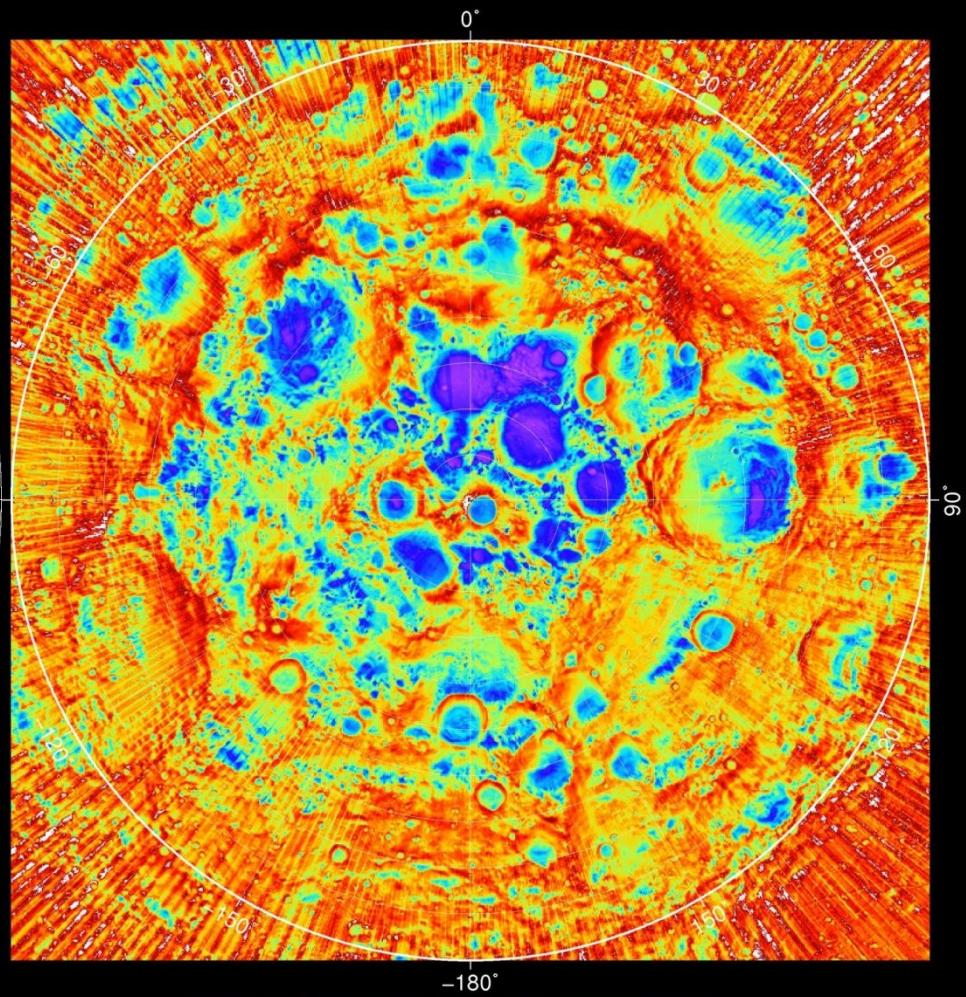
LROC WAC South Pole Mosaic
Polar Stereographic, 400 m/pixel
Arizona State University



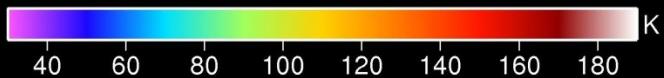
Time spent in
sunlight during
lunar day



LROC WAC South Pole Mosaic
Polar Stereographic, 400 m/pixel
Arizona State University

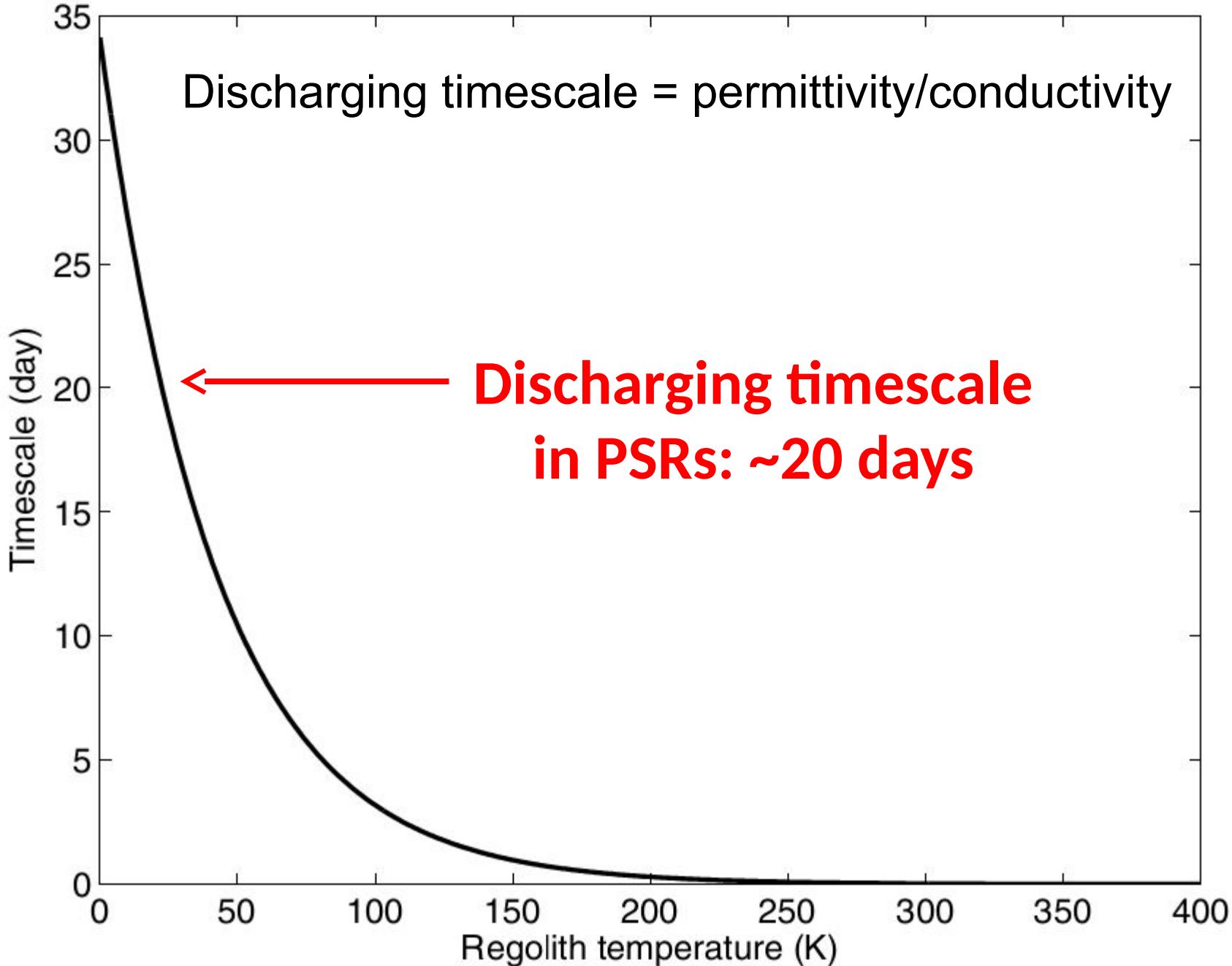


Average Bolometric Temperature

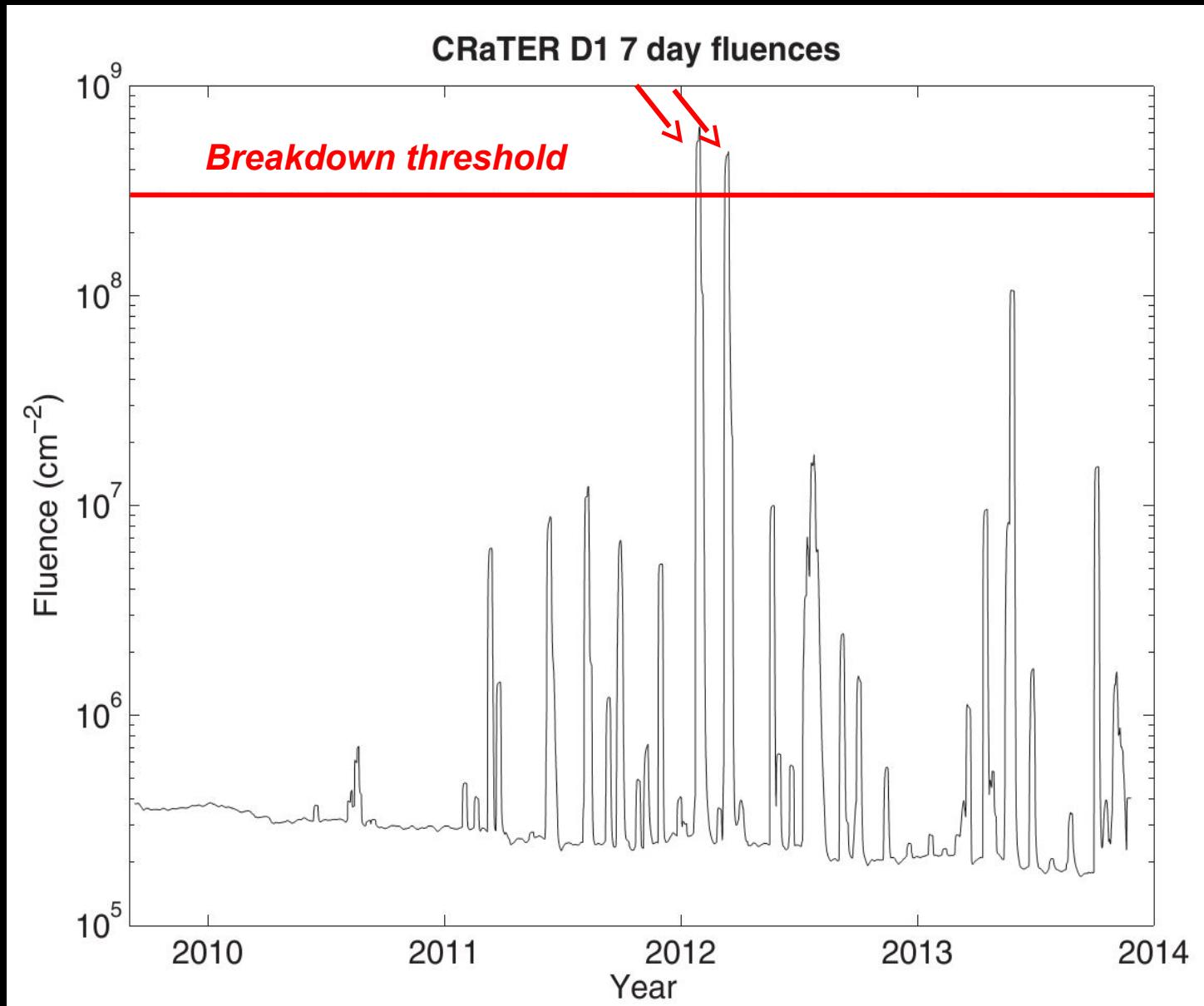


(Paige et al., 2010)

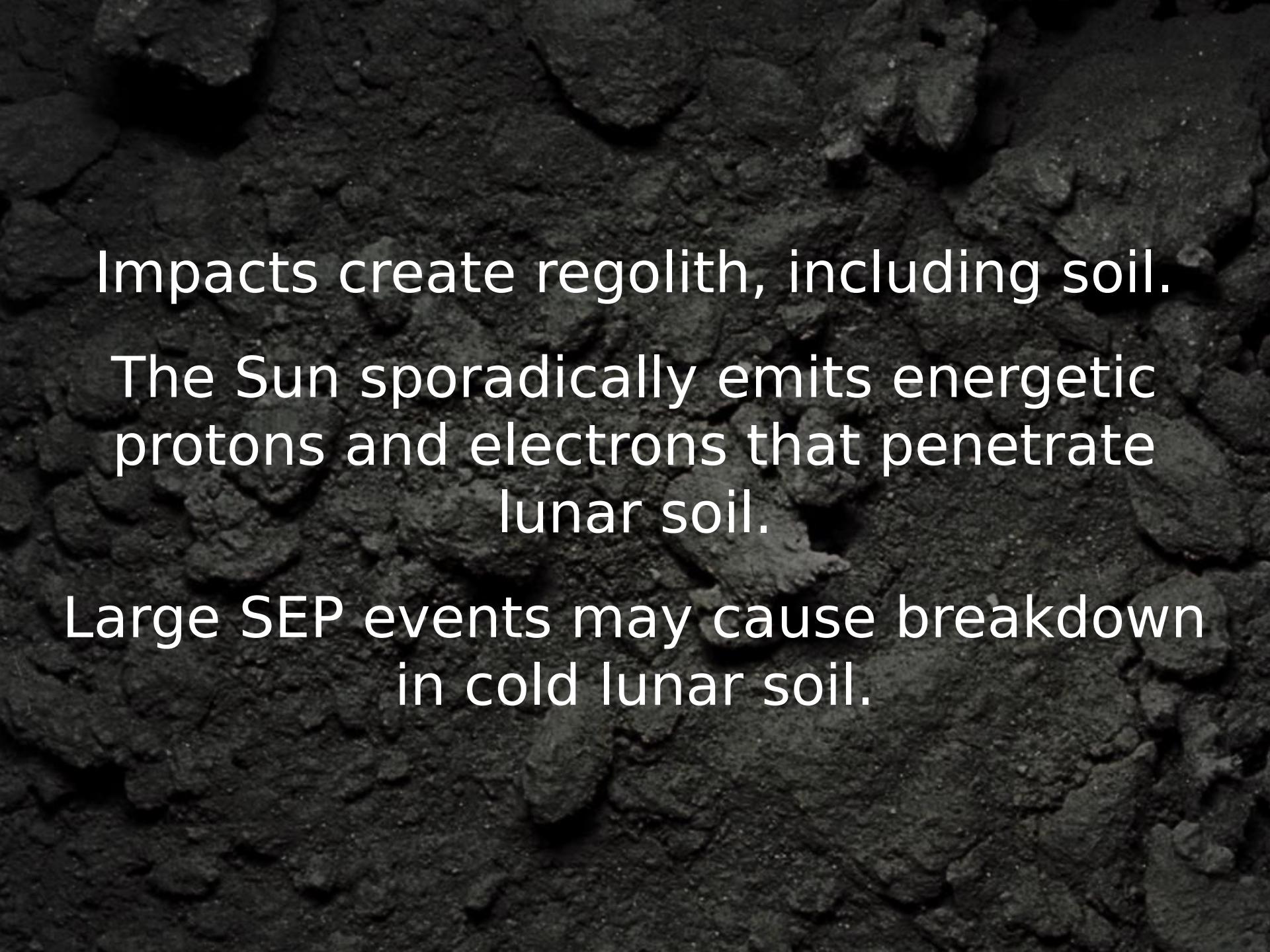
Regolith's discharging timescale



Breakdown may have
happened recently



(Jordan et al., 2015)

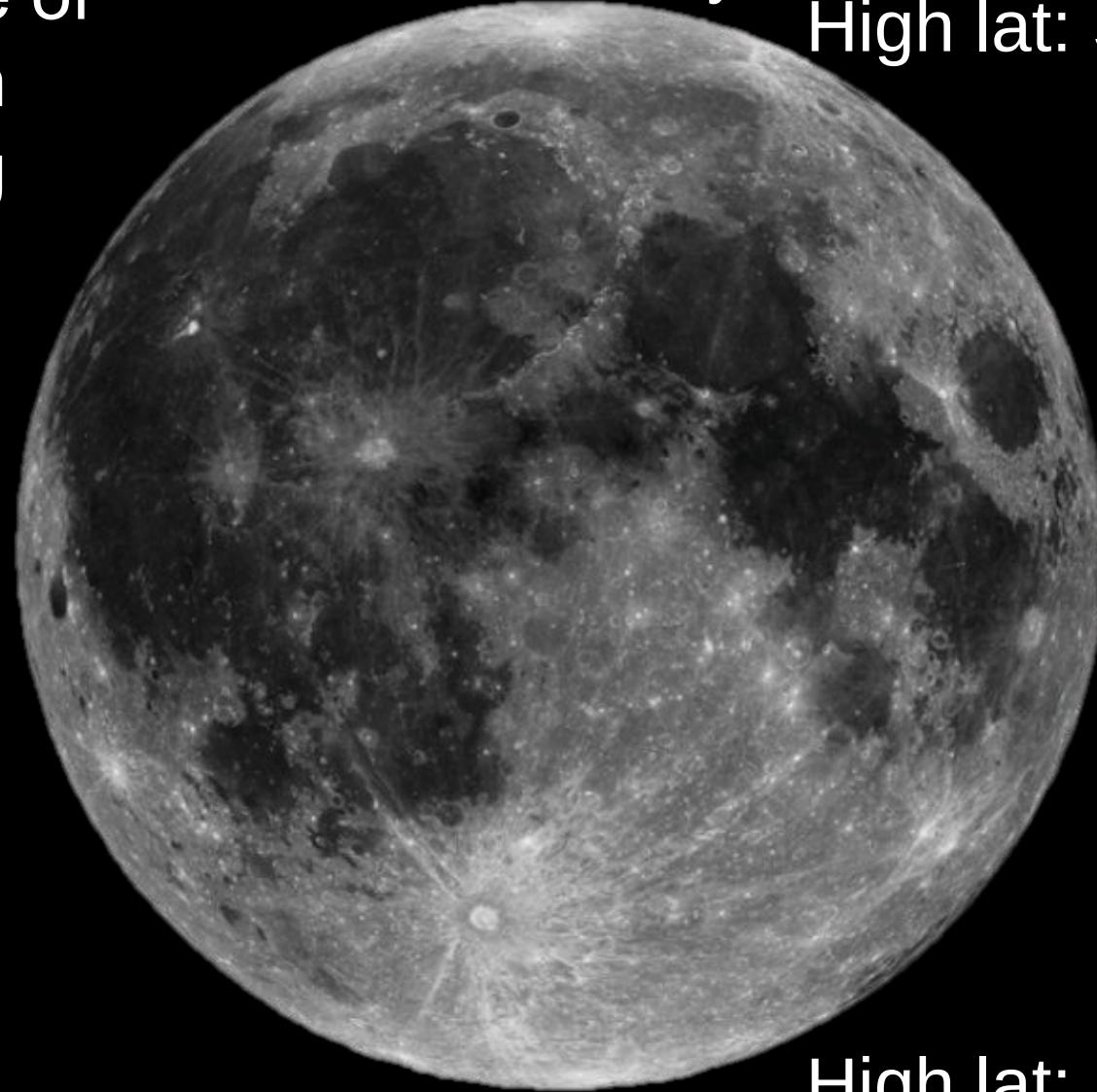


Impacts create regolith, including soil.

The Sun sporadically emits energetic protons and electrons that penetrate lunar soil.

Large SEP events may cause breakdown in cold lunar soil.

Possible importance of breakdown weathering



PSRs: Very

High lat: Somewhat

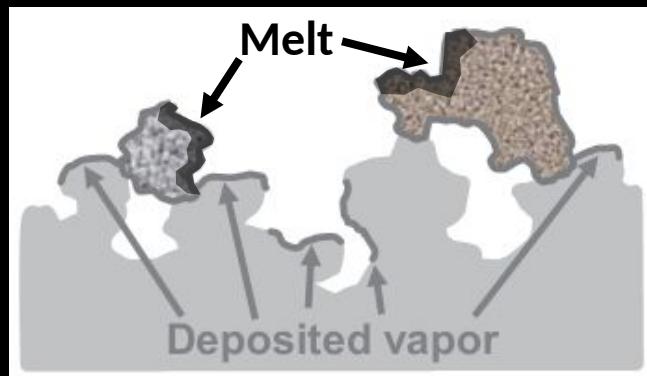
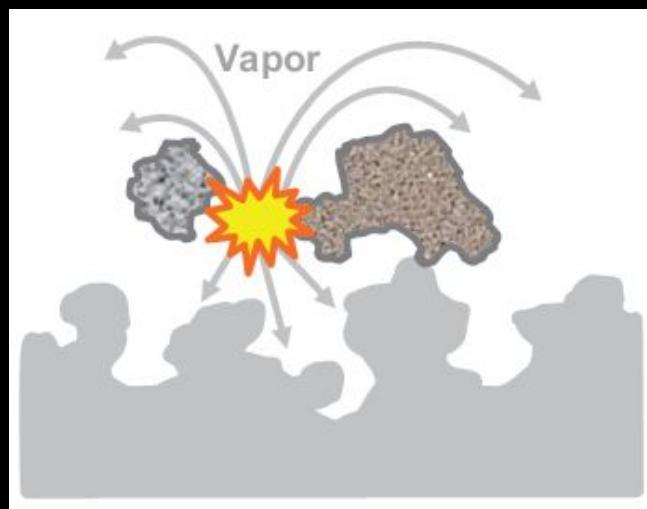
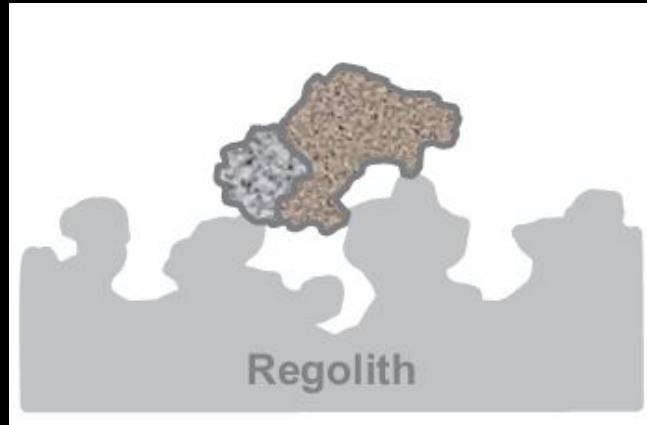
PSRs: Very

Low lat:
A little

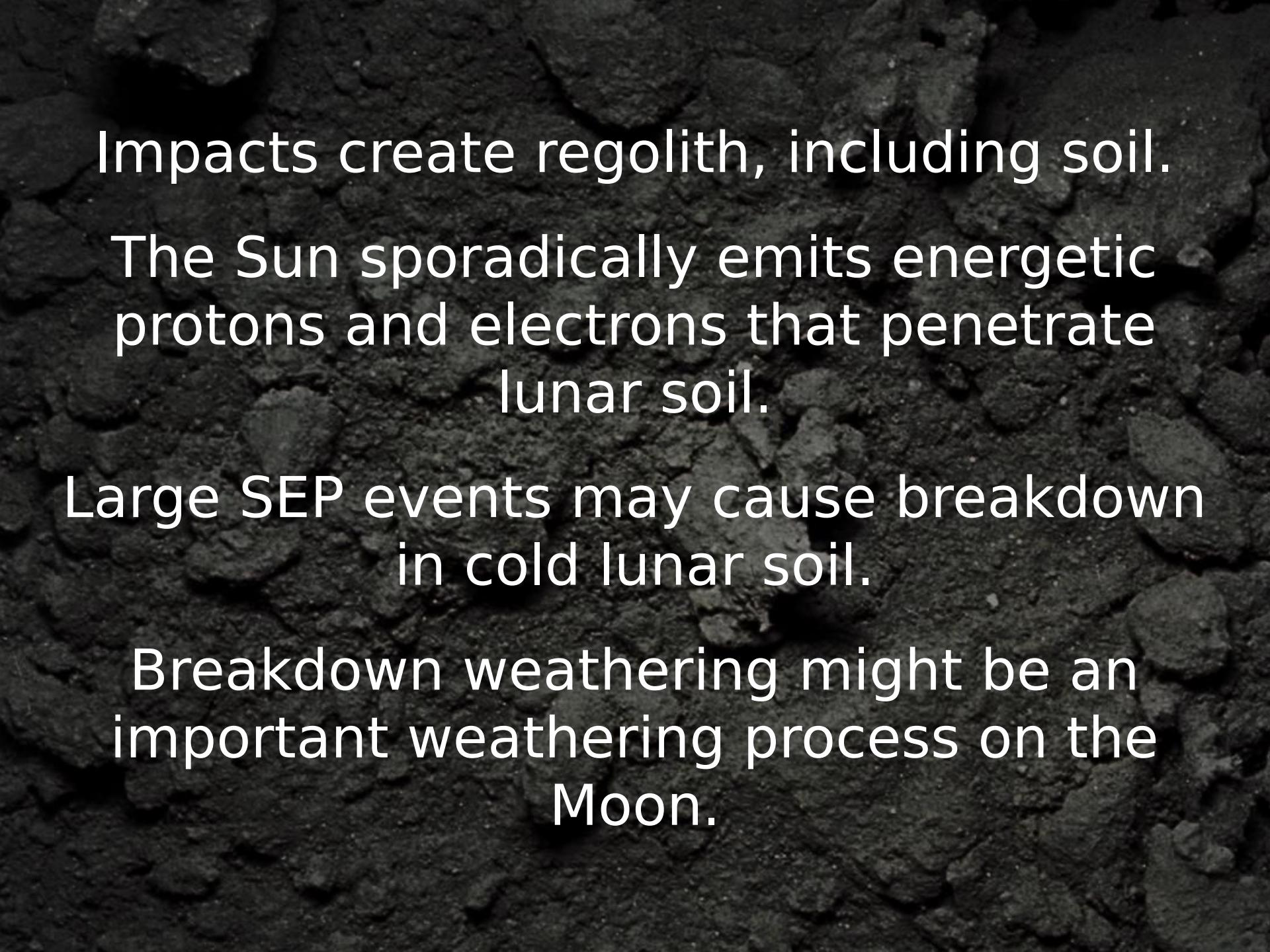
High lat: Somewhat







Jordan et al. (2015)

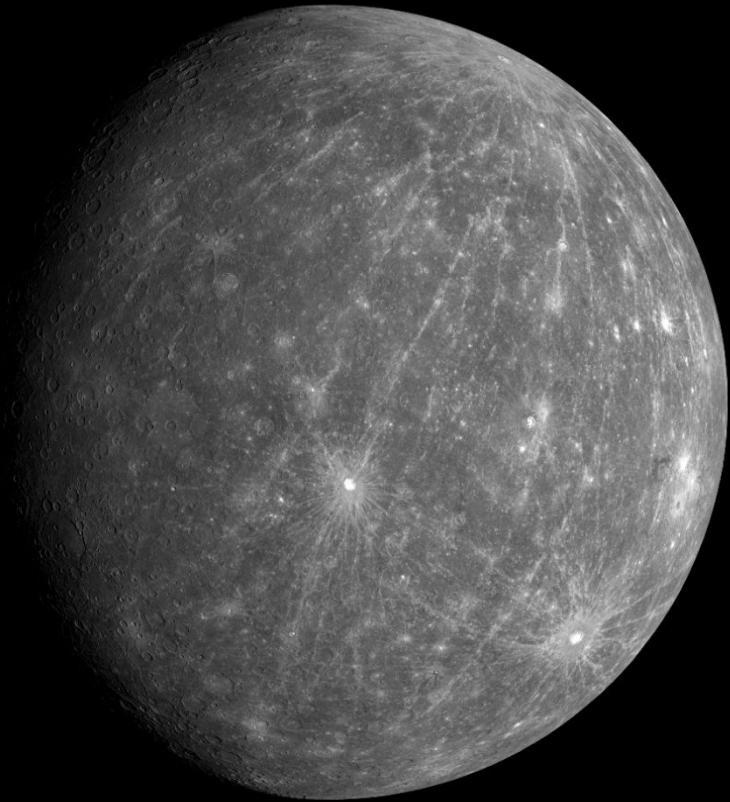


Impacts create regolith, including soil.

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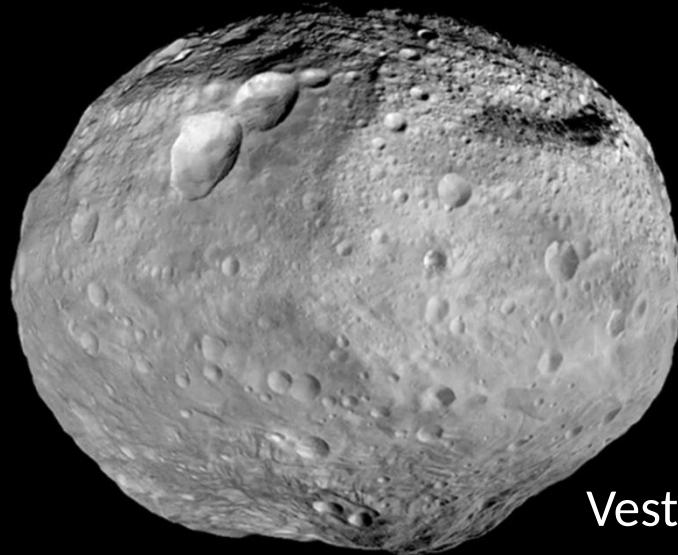
Breakdown weathering might be an important weathering process on the Moon.



Mercury

PSRs: <100 K (Paige et al., 2013)

Nightside: Similar to Moon
(Vasavada et al., 1999)

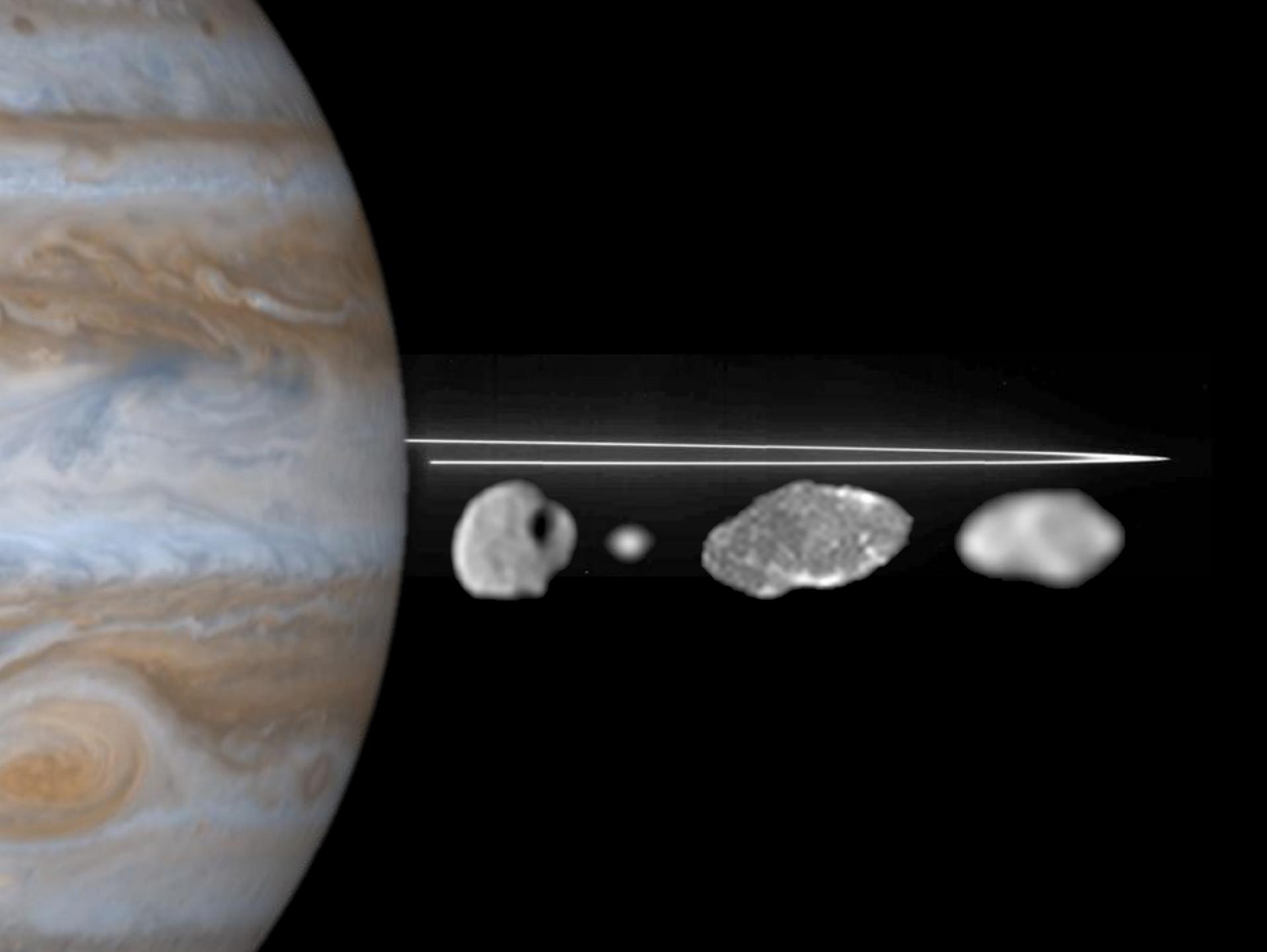


Vesta

High-obliquity asteroids

Poles: In shadow for long time

Polar craters: Avg. temp. <100 K
(Stubbs and Wang, 2012)



Conclusions

- Breakdown weathering may have significantly affected lunar regolith
- The conditions for breakdown weathering occur elsewhere in the Solar System

Future Work

- Can remote/in situ observations + lab work show if breakdown weathering has occurred?
- Can breakdown be detected as it occurs?
- Could “sparked” material be in the Apollo samples?